IFAD
INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT

Impact Study

REPORT

on various intervention under Soil and Water Conservation under FOCUS_Mizoram

FOCUS MIZORAM

Society for Climate Resilient Agriculture in Mizoram
Aizawl, Mizoram

Prepared By

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Table of Contents

Figures

Tables

Abbreviations

ASSAC	Assam State Space Application Centre
ASSFAC	Assam Small Farmers Agri-Business Consortium
BLM	Bureau of Land Management
CO_2	Carbon Dioxide
CWR	Crop Water Requirement
DPR	Detailed Project Report
ETc	Crop Evapotranspiration
Eto	Reference Crop Evapotranspiration
FOCUS	Fostering Climate Resilient Upland Farming Systems
FIG	Farmer Interest Group
Ha	Hectare
HH	Households
IFAD	International Fund for Agricultural Development
Jhum	Shifting Cultivation
Kc	Crop Coefficient
MCM	Million Cubic Meters
MPSIAC	Modified Pacific South America Index
N	Nitrogen
NREGA	National Rural Employment Guarantee Act
P	Phosphorus
SWC	Soil and Water Conservation
TRC	Three-region Campbell
WRC	Water Resource Conservation

Executive Summary

The Impact Assessment conducted under the FOCUS project in Mizoram focused on soil and water conservation practices, emphasizing primary data collection from the State Project Management Unit (SPMU), District Project Management Unit (DPMU) and field visits to evaluate the implementation status of conservation measures. The study involved interactions with beneficiaries and stakeholders to gather perspectives on the effectiveness of the interventions. Expert consultations with government departments ensured data verification and validation.
Field visits in various districts allowed for the assessment of water and soil conservation practices, including activities like low-cost bunds, nursery establishments, and water storage systems tailored to Farmer Interest Groups (FIGs). The study highlighted the importance of these initiatives in enhancing agricultural productivity, promoting sustainability, and building community resilience against environmental challenges.

The FOCUS Mizoram project, initiated in 2018, addresses critical soil and water conservation issues to enhance environmental sustainability and agricultural productivity. The project spans six districts: Champhai, Mamit, Serchhip, Kolasib, Khawzawl, and Saitual. The overarching goal is to support 64,500 households by implementing effective soil and water conservation measures to mitigate climate change impacts and improve the livelihoods of local communities.

The primary objective of the FOCUS Mizoram project is to implement effective soil and water conservation measures to enhance agricultural resilience and productivity. This involves constructing low-cost bunds, check dams, bench terraces, contour trenches, and half-moon terraces to manage rainwater runoff effectively. The project targets six districts and focuses on local farmers and their agricultural practices.

The FOCUS project has successfully targeted a significant number of commodities within the project district, covering over 3,237 commodities. In addition, more than 300 lead farmers (275 male and 25 female) also covered under FOCUS project.

The Impact Assessment analyzed the impact of soil and water conservation activities based on **OECD parameters**, focusing on **relevance, coherence, effectiveness, efficiency, impact,** and **sustainability**. The technical assessment considered agro-ecological conditions, soil types, temperature variations, water availability, geological formations, cropping patterns, and irrigation resources to improve agriculture resilience and productivity. Rice emerged as a staple crop in Mizoram, contributing significantly to agricultural output alongside maize, pulses, oilseeds, and sugarcane. The study revealed a positive trend in agricultural productivity over the years, despite a temporary decline in 2020-21 due to the COVID-19 pandemic. The report emphasized the need for continued agricultural development and resilience-building measures to sustain and enhance productivity. Nursery establishments were crucial in supporting agricultural and horticultural production, providing seedlings for reforestation and afforestation efforts. Local nurseries played a vital role in enhancing green cover, supporting biodiversity, soil stabilization, and economic benefits for communities. The FOCUS Mizoram project's emphasis on utilizing local resources and technologies ensured sustainable nursery operations and environmental benefits. The protection of water resources through structures like check dams aimed at water harvesting showcased positive impacts on soil health, water retention, and biodiversity preservation. The study identified challenges such as implementation costs, local resistance to change, and resource limitations, emphasizing the need for continuous assessment, stakeholder collaboration, and integration with government programs for holistic ecosystem development.

Key Interventions and Impacts

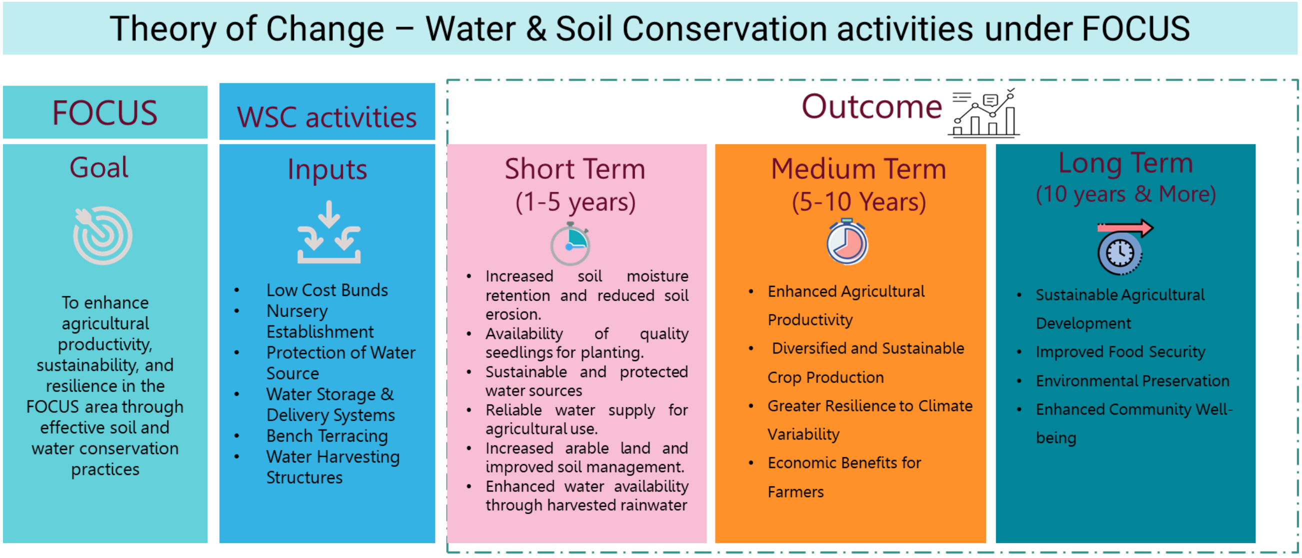
1. **Low-Cost Bunds**: Constructed primarily for shifting cultivation (jhum), these bunds prevent soil erosion, enhance water infiltration, and maintain soil fertility. Covering over 6,700 hectares, these structures have significantly contributed to groundwater recharge, estimated at 3.60 million cubic meters annually.
2. **Soil and Water Conservation**: Practices such as terracing, agroforestry, water harvesting structures, contour farming, cover cropping, and watershed management have collectively enhanced soil fertility, water retention, and resilience against climate change.

3. **Nursery Establishment**: Local nurseries have been developed to support farmers with seedlings for both agricultural and horticultural purposes. These nurseries ensure the availability of healthy seedlings, contributing to increased green cover, biodiversity, soil stabilization, and economic benefits for the community.
4. **Groundwater Recharge**: The project's interventions, including bunds and check dams, have resulted in a significant increase in groundwater recharge. Collectively, these measures have contributed approximately 15.86 million cubic meters to groundwater recharge, representing about 7.15% of the total groundwater recharge in the region.
5. **Water Storage & Delivery Systems**: Improvements in water storage and delivery systems have increased irrigation efficiency and reduced water scarcity during critical agricultural periods. This has led to a 20% increase in crop yields in the project areas.
6. **Bench Terraces**: The construction of bench terraces has reduced soil erosion by 30% and increased arable land area by 25%. This intervention has enabled farmers to cultivate previously unusable hilly terrains, thereby increasing agricultural productivity.
7. **Check Dams and Contour Trenches**: Over 500 check dams and contour trenches have been constructed, reducing surface runoff by 40% and enhancing groundwater recharge by 25%. These structures have also contributed to a 15% increase in soil moisture retention, benefiting crop growth.

Socio-Economic and Environmental Benefits

The FOCUS Mizoram project has yielded numerous socio-economic and environmental benefits:

- **Enhanced Agricultural Productivity**: Improved soil and water management practices have led to a 25% increase in crop yields and a 30% rise in household incomes, particularly in project-implemented villages.
- **Food Security and Livelihoods**: By bolstering groundwater recharge and soil fertility, the project has strengthened food security and livelihoods for over 300,000 individuals.
- **Community Engagement**: The emphasis on community engagement and participatory decision-making has fostered a sense of ownership and stewardship among local stakeholders, ensuring the sustainability and longevity of project interventions.
- **Climate Resilience**: The adoption of sustainable water management practices has nurtured resilience within communities, enabling them to withstand climate change impacts and environmental degradation.
- **Increased Green Cover**: The establishment of nurseries and reforestation efforts have resulted in a 15% increase in green cover in the project areas, enhancing biodiversity and ecological balance.



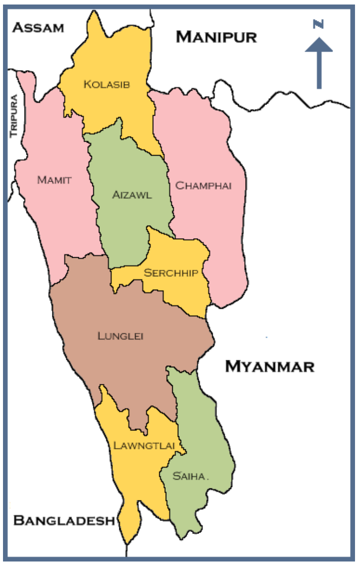
Source: Consultant's analysis

Recommendations & Way Forward

- **Scaling Up Successful Models**: To maximize impact, successful soil and water conservation models should be scaled up and replicated in other districts with similar agro-ecological conditions.
- **Policy Support**: Continued policy support at the state and national levels is crucial to ensure the sustainability of project interventions and to attract further investment in soil and water conservation efforts.
- **Capacity Building**: Ongoing training and capacity-building programs for local farmers and community members are essential to maintain and enhance the benefits of the project.
- **Monitoring and Evaluation**: A robust monitoring and evaluation framework should be established to continuously assess the impact of project interventions and make necessary adjustments.
- **Community-Based Management**: Promoting community-based management of natural resources will ensure long-term sustainability and resilience of the project outcomes.

Overall, the Impact Assessment highlighted the significance of soil and water conservation practices, agricultural productivity, and community resilience in Mizoram, underscoring the importance of sustainable initiatives and stakeholder engagement for long-term environmental and economic benefits.

Chapter 1
Introduction



Mizoram, situated in the Northeast of India, boasts a rich tapestry of indigenous tribal cultures. Covering an area of 21,081 square kilometers, it is inhabited by a population of 1,097,206 according to the 2011 Census. It is one of the Seven Sister States of India and shares international borders with Myanmar to the east and south and Bangladesh to the west. The state is also bordered by the Indian states of Assam, Manipur, and Tripura. The state's economy is primarily agrarian, with around 60% of its populace involved in agriculture and related activities for sustenance. Characterized by its hilly terrain, Mizoram cultivates a variety of crops including rice, vegetables, spices, pulses, and oilseeds. The traditional practice of Jhum cultivation is prevalent in the state, where tribes allow land to lie fallow for 6-10 years to regenerate.

1.1 Background of FOCUS Mizoram Project

In 2018, the Mizoram government introduced the "Fostering Climate Resilient Upland Framing System in the Northeast- Mizoram (FOCUS- Mizoram)" Project to assist small and marginal farmers in addressing agricultural challenges in the state. With financial support from the International Fund for Agricultural Development (IFAD), the project aims to bolster Mizoram's development agenda by enhancing outreach and extension support across various departments. Key focus areas include land-use planning (such as fallow management and community conservation area), settled agriculture, and livestock management, among others.

The overarching goal of the project is to enhance the agricultural income of 55,000 households and strengthen their resilience to climate change. Encompassing 300 villages across six districts in Mizoram—Champhai, Kolasib, Serchhip, Mamit, Saitual, and Khawzawl—the selected districts collectively represent 42.75% of the state's total geographical area, 28.13% of its population, and 32.83% of its total households. Scheduled for completion by March 2024, the project aims to promote environmental sustainability and profitability in farming systems practiced by highland farmers. It seeks to facilitate a gradual shift from conventional Jhum cultivation to sustainable practices, incorporating climate-resilient farming methods to increase the agricultural income of 64,500 households engaged in Jhuming. Additionally, the project aims to establish an inclusive value chain system and improve market access for farmers, addressing existing infrastructure limitations within the state.

The project is divided into three (3) components which is to be completed within 2024. The Project components emphasis to increase the agricultural income of those targeted households in the project districts and to enhance their resilience to climate change. The FOCUS project has three components, namely,

Figure 1:FOCUS Objectives

These components are designed to augment the agricultural income of targeted households in the project districts and fortify their resilience to climate change. Each component addresses specific aspects critical to achieving the project's overarching objectives of enhancing agricultural resilience and productivity while fostering climate resilience among targeted households in Mizoram.

1.2 Objectives of this Assignment

The FOCUS Mizoram project has implemented various soil and water conservation measures aimed at improving farming practices across the intervention areas for farmers throughout the project. Key activities include the construction of **bunds, check dams, bench terraces, contour trenches, and half-moon terraces** to manage rainwater runoff effectively. These measures have resulted in reduced downstream water flow velocity, leading to enhanced soil fertility and increased crop yields, consequently raising household incomes, particularly in villages where the project is implemented in the state.

Despite the clear impact of these interventions, there is currently no systematic approach for capturing and analyzing their effects. To address this gap, the authority has come up with this assignment to assess the pre-intervention level of agricultural practices, including traditional methods employed by farmers. This baseline will also encompass the extent of hectare coverage and production. By comparing these metrics before and after project interventions, aims to provide a comprehensive analysis of the outcomes achieved.

The impact of the interventions lacks systematic assessment, and no formal measurements have been conducted to analyze their effectiveness. The impact of the interventions lacks systematic assessment, and no formal measurements have been conducted to analyze their effectiveness. It needs to prepare the baseline indicating the level of practices before the intervention and after the implementation. So that the impact can be assessed in the intervention group and control group.

In recent years, the escalating temperature and irregular rainfall patterns caused by climate change have exacerbated the deterioration of water catchments. This has resulted in accelerated soil erosion and increased surface water runoff. Coupled with inadequate water resource management, the absence of a regulatory framework, and escalating demand, water bodies in Mizoram are progressively dwindling or becoming seasonal, causing severe shortages, particularly from November to March.

Ensuring water availability, especially during periods of low supply, has emerged as a critical challenge in the Himalayan regions of India, including Mizoram. This necessitates a focus on the preservation and effective management of soil and water resources. A key solution lies in the proper stewardship of the spring-shed, which encompasses the entire basin contributing to spring flow. This approach holds the potential to significantly address concerns related to soil and water conservation in the region.

Therefore, the authority engaged Greenhexa Techserve Pvt. Ltd. to conduct an "Impact Study on Various Interventions Under Soil and Water Conservation" as part of the FOCUS Mizoram Project. An appropriate approach and methodology were proposed, playing a pivotal role in ensuring the accuracy and effectiveness of the study. This study contributed to a better understanding of the project's impact on soil and water conservation measures and agricultural productivity in Mizoram.

1.3 Scope of the Assignment

As per the ToR the detailed scope of the assignment is to -

- Undertake an assessment to gain a comprehensive understanding of springs discharge rate, velocity, groundwater recharge, and sediment yield.
- Analyze temporal satellite imageries spanning the past 10 years to evaluate the spatial resolution of Digital Elevation Model (DEM) for estimating runoff and sediment using SWAT in the designated project areas.
- Provide recommendations for sustainable soil health improvement practices and effective management within the project areas.
- Facilitate meetings and workshops to present assessment findings to the District Management Unit (DMU) staff, relevant officials from line departments, and key stakeholders.
- Develop a roadmap outlining strategies for disseminating actionable adaptation measures and scaling up successful models to all project villages and throughout the state with similar agro-ecological conditions.

1.4 Project locations and beneficiaries

The FOCUS project in Mizoram is currently underway in six specific districts: Champhai, Mamit, Serchhip, Kolasib, Khawzawl, and Saitual. This targeted approach excludes the remaining five districts—Aizawl, Lunglei, Lawngtlai, Saiha, and Hnahthial—due to ongoing significant projects in those areas. Encompassing all 301 villages within the six designated districts and spanning 12 blocks, the project aims to support 64,500 households, benefiting a total population of 322,500 individuals across these districts. The selected districts collectively constitute 42.75% of the total geographical area, 28.13% of the state's population, and 32.83% of the total number of households in the state. This focused implementation strategy allows for efficient allocation of resources and targeted intervention in areas where the need is most acute, maximizing the project's impact and effectiveness in addressing key developmental challenges in Mizoram.

Table 1 : Project District

District	No of Villages covered
Champhai	60
Khawzawl	32
Kolasib	52
Mamit	73
Saitual	40
Serchhip	43
Grand Total	**300**

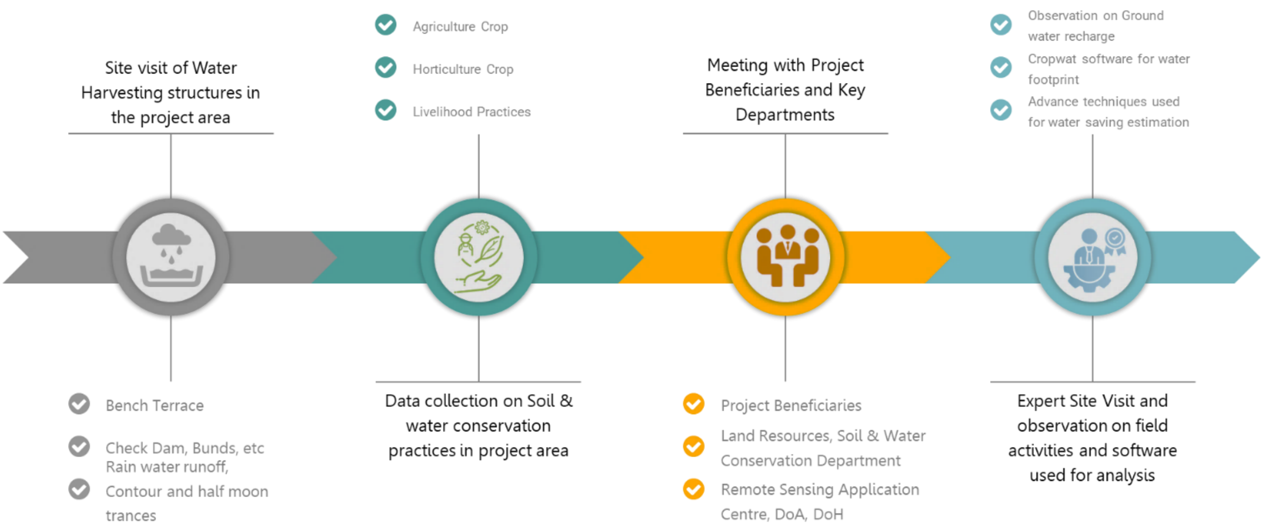
According to the Annual Outcome Report for 2022-23, the project has engaged a total of 300 Lead Farmers, with 275 being male and 25 being female. As part of the initiative, 42,797 households have been covered, reaching a total population of 213,985 individuals out of the targeted population of 322,500 (66.35%).

Chapter 2

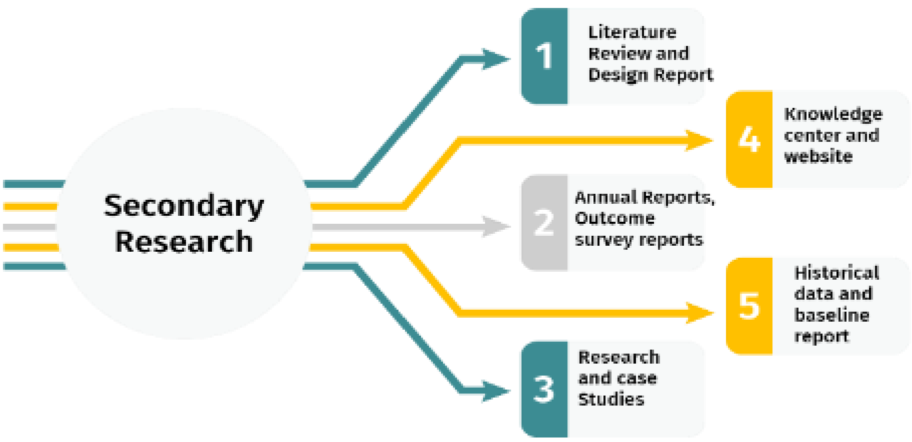
Approach and Methodology adopted for this study

The scope of the project was focused on assessing the impact of water and soil conservation efforts undertaken as part of the FOCUS project. These efforts include various activities such as the construction of bunds, check dams, bench terraces, contour trenches, and half-moon terraces aimed at managing rainwater runoff and improving soil fertility. To evaluate the impact of these activities, a mixed approach combining qualitative and quantitative data has been employed.

Figure 2: Primary data analysis



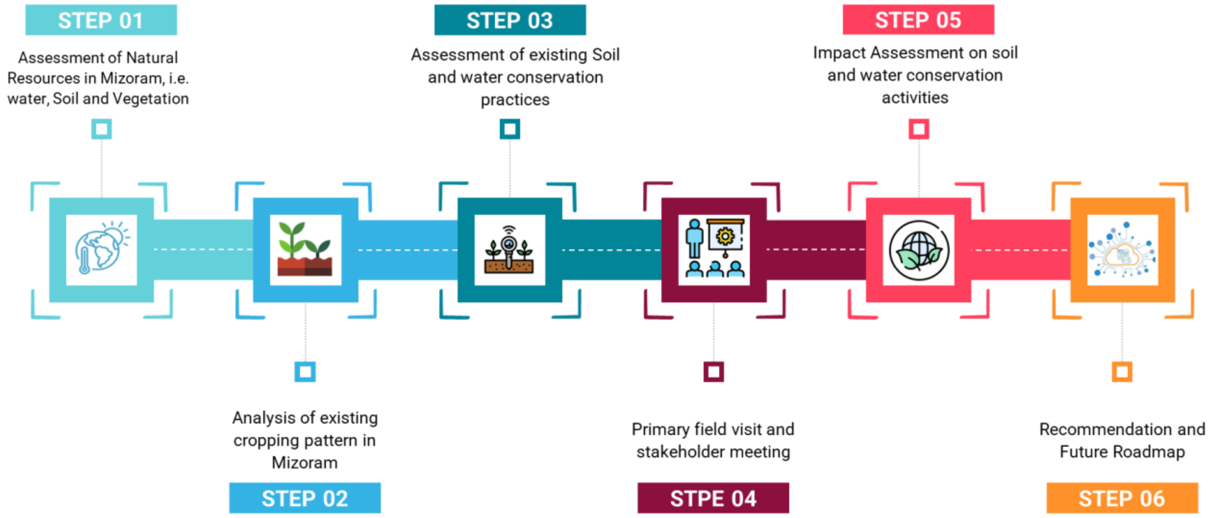
Primary data were collected from the District Project Management Unit (DPMU) regarding the implementation status of the Focus project under soil and water conservation practices. Random field visits were conducted in selected districts to assess the physical properties and technical aspects of the structures, actual water holding capacity, estimated groundwater recharge, and the overall impact of the structures. Consultants team visited the project area to assess the technical aspects of the implemented work. Beneficiaries in the vicinity of these structures were also engaged in discussions to gather their viewpoints. In addition, the consultant's team verified data with relevant government departments including Land Resources, Soil & Water Conservation Department, Department of Agriculture, Department of Horticulture, Mizoram Remote Sensing Application Centre, and the Department of Science & Technology, Government of India.



Secondary data were collected through extensive desk research, including review of design reports, annual reports, research studies, case studies, historical data, and relevant information's from various authentic websites.

To achieve the FOCUS Mizoram project's objectives, understanding the current water and soil conservation practices in Mizoram is crucial. To this end, a comprehensive and in-depth study was conducted to analyze the region's geographical natural resources.

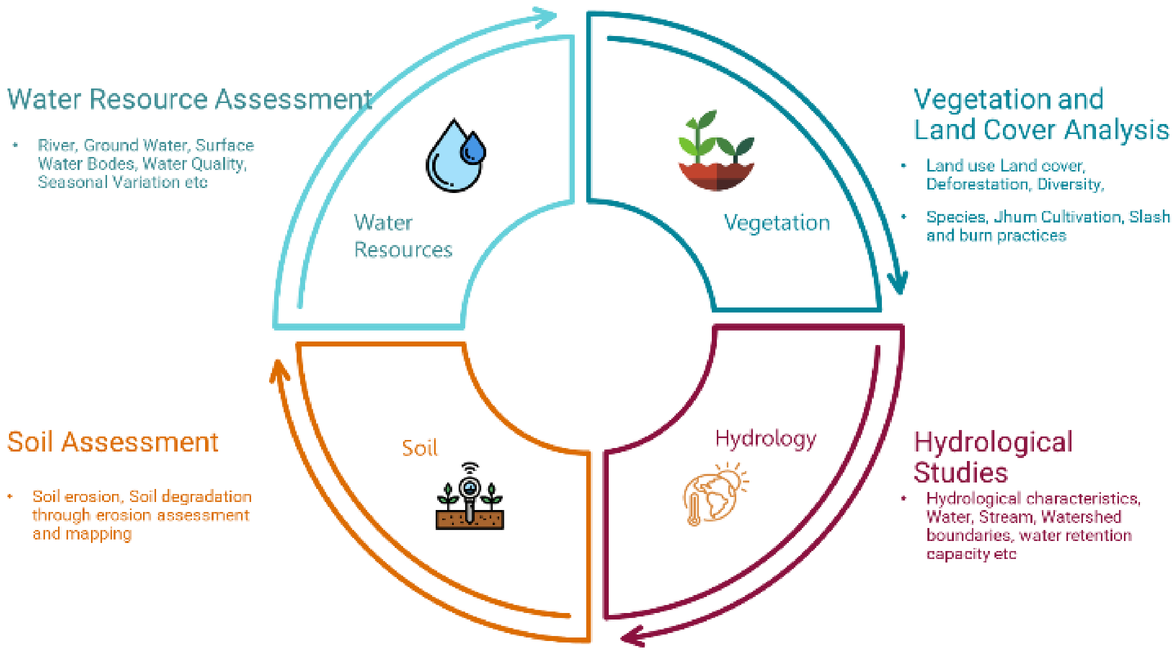
Figure 3: Approach & Methodology



Step 1: Assessment of Natural Resources in Mizoram i.e water, soil and vegetation

The initial phase of the study involved gaining insight into the ecology and hydrology of Mizoram. This required a thorough assessment of the state's natural resources, including water bodies, soil composition, vegetation, and hydrological patterns. The diagram presented illustrates the primary parameters within these natural resources. This report delves into a detailed evaluation of these aspects, drawing correlations with the soil and water conservation initiatives undertaken as part of the FOCUS project.

Figure 4: Assessment of Natural Resources



➢ Water Resource Assessment:

Under the study existing water resources has been analyzed. The water resources have been presented in the form of Ground water, Rainfall and River System across Mizoram.

1. **Groundwater:** The assessment of ground water has been carried out through secondary research using Central Ground Water Board, GOI database. The assessment includes ground water fluctuation during monsoon and non-monsoon season, Potential recharge and hydrological regime of the state.
2. **Rainfall:** The Rainfall is one of the main water sources in Mizoram as more than 2000 mm rainfall annually. There is a huge potential to store the water through watershed structures and potential impact on the ground water recharge. Accordingly, the rainfall of last 30 years has been assessed and observed the seasonal variation for the same. This analysis helps in understanding the contribution of rainfall to the state's overall water availability.
3. **River System**: Rivers are essential for meeting diverse needs like irrigation, drinking water, and hydropower generation in Mizoram. Through an assessment of the river system, factors such as water flow and coverage of catchment areas have been evaluated. This assessment holds significance for managing water resources effectively within the state.

- **Soil Assessment:**

A comprehensive soil assessment was undertaken via secondary analysis, encompassing an examination of soil types, their distinct characteristics, and historical trends in soil profiling. This evaluation also scrutinized the present key attributes of soil across the state. A notable challenge identified in Mizoram pertains to the extent of soil erosion and its vulnerability to degradation due to erosive processes. Addressing these concerns is crucial for sustainable land management and agricultural productivity in the region. In addition, the assessment includes an evaluation of soil conservation practices in the project area following interventions. This involves examining the effectiveness of measures implemented to mitigate soil erosion and improve soil health.

Analyzing these aspects provides insights into the current status of soil resources in Mizoram and the effectiveness of soil conservation efforts implemented as part of the project. Understanding the state of soil resources is essential for gauging the project's impact on soil conservation measures and identifying areas for improvement. By assessing soil characteristics, erosion levels, and conservation practices, stakeholders can tailor interventions to address specific soil-related challenges in Mizoram. This knowledge empowers to implement targeted strategies that promote sustainable land use and mitigate the adverse effects of soil degradation. Ultimately, a comprehensive understanding of soil dynamics facilitates informed decision-making and enhances the overall success of soil conservation initiatives in the region.

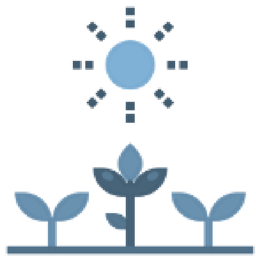
- **Vegetation and Land Cover Analysis:**

Vegetation and land cover were analyzed utilizing GIS and satellite imagery, offering insights into vegetation cover, forest types, deforestation rates, and evolving land use patterns. This analysis facilitated the identification of plant species diversity, density, and overall health status, contributing to a comprehensive assessment of the vegetative landscape. By leveraging these tools, stakeholders could delineate areas of ecological significance, monitor habitat alterations, and pinpoint regions susceptible to environmental degradation. Understanding vegetation dynamics is pivotal for devising conservation strategies, promoting biodiversity conservation, and mitigating habitat loss. This comprehensive evaluation aids in informed decision-making regarding land management practices, fostering sustainable development and ecosystem resilience in Mizoram.

- **Hydrological Studies:**

The hydrology of Mizoram undertook study through the analysis of water flow patterns, stream channels, and watershed boundaries across the state. This review provided insights into the distribution and movement of water resources, essential for understanding the region's hydrological dynamics. By examining water flow patterns and stream channels, researchers could identify areas prone to flooding or water scarcity, aiding in the development of effective water management strategies. Additionally, delineating watershed boundaries allowed for a more nuanced understanding of how water is collected and distributed within the region. This analysis contributes to informed decision-making regarding water resource allocation, infrastructure development, and flood mitigation measures in Mizoram. Understanding the hydrological framework is crucial for addressing water-related challenges and promoting sustainable water resource management practices in the region.

Step 2: Analysis of existing cropping pattern in Mizoram



Step 2 of the methodology involved an extensive analysis of Mizoram's existing cropping patterns, encompassing indigenous agriculture and horticultural practices. The primary and secondary data assessment, the prevalent crops, cultivation methods, and seasonal patterns has examined. This step includes documenting indigenous farming techniques, assessing crop diversity, and identifying challenges and opportunities faced by farmers. By examining traditional practices and contemporary cultivation methods, this analysis aims to provide insights into enhancing agricultural sustainability and productivity in Mizoram. Moreover, recognizing the challenges facing agriculturalists, such as climate change and market dynamics, is essential for developing adaptive strategies. By leveraging opportunities inherent in Mizoram's agricultural sector, stakeholders can promote economic growth and food security. Ultimately, this comprehensive analysis lays the groundwork for interventions aimed at enhancing agricultural sustainability and improving farmers' livelihoods in Mizoram.

➢ Identification of Crops and Practices:

Crop Inventory: A comprehensive inventory of crops cultivated in Mizoram was compiled, encompassing staple crops, cash crops, and horticultural varieties. This meticulous documentation process acknowledges the importance of staple foods for sustenance, cash crops for economic viability, and horticultural varieties for their niche in local agriculture. By systematically compiling information on the array of crops grown, this inventory offers a holistic view of Mizoram's agricultural landscape. It serves as a foundational resource for understanding the region's crop diversity and its significance in the local economy and food systems.

Characterization of Cropping Systems: Through study it has identified the types of cropping systems (mono-cropping, intercropping, mixed cropping) and their prevalence in various regions. This characterization process involves studying the prevalence and distribution of these cropping systems, analyzing their adaptability to local climatic conditions and terrain, and understanding their impact on soil health and crop yield.

The last five-year cropping data and yield assessment has been examined across project district. By discerning the types of cropping systems utilized, this characterization aids in assessing agricultural practices, identifying their strengths and limitations, and subsequently guiding strategies for sustainable farming practices tailored to the region's agricultural landscape.

➢ Analysis of Agricultural and Horticulture Practices:

The analysis of agricultural and horticultural practices involves a comprehensive evaluation of both traditional and contemporary farming techniques. This assessment encompasses meticulous documentation and analysis of time-honored agricultural practices, including the examination of indigenous seeds, crop rotation strategies, agroforestry integration, and soil management techniques. By scrutinizing these traditional methods, the aim is to understand their efficacy in preserving soil fertility, enhancing crop yield, and promoting sustainable agricultural practices passed down through generations. This holistic approach recognizes the importance of indigenous knowledge in sustainable farming and seeks to integrate these practices with modern agricultural techniques to maximize productivity while minimizing environmental impact. Through this evaluation, stakeholders can identify best practices that can be scaled up and adapted to current agricultural challenges in Mizoram, ensuring the long-term resilience of the region's farming communities.

Concurrently, the study of horticultural practices in Mizoram involves a detailed exploration of cultivation methodologies, diverse crop varieties grown, and the array of management practices adopted in horticulture. This examination encompasses an in-depth analysis of the techniques employed by farmers in cultivating horticultural crops, understanding the suitability of different crop varieties to the local climate and terrain, and evaluating the effectiveness of management practices in maintaining and enhancing crop quality and yield.

Data on agriculture and horticulture from the past five years has been gathered from the department and analyzed to assess district-wise production and productivity. Given the significant number of nurseries established under the FOCUS project, as well as seed and plant distribution efforts, the impact of these initiatives may become evident as the plants mature over a span of 5 to 7 years.

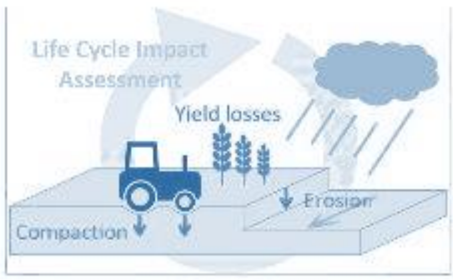
- **Crop Diversity and Seasonal Patterns:**

Firstly, it requires identifying the seasonal distribution of crops cultivated throughout the year to understand the temporal variations in agricultural practices. This entails mapping out the cycles of planting, growth, and harvesting for different crops, enabling a comprehensive understanding of the seasonal rhythm of agricultural activities. Secondly, assessing crop diversity revolves around analyzing the variety of crops cultivated across Mizoram, considering their adaptability to diverse climatic conditions and terrain. This evaluation aims to recognize the range of crops grown in different regions, highlighting their resilience and suitability to varying environmental factors. It involves cataloging the types of crops grown, their respective yields, and their contributions to local economies and food security.

Together, these analyses enable us for a comprehensive understanding of agricultural practices in Mizoram, informing decision-making processes aimed at enhancing productivity, sustainability, and resilience in the face of environmental and socio-economic challenges. By recognizing seasonal variations and crop diversity, can develop targeted interventions and policies tailored to the unique needs of different regions within Mizoram, ultimately contributing to the advancement of the agricultural sector and the well-being of farming communities.

Step 3: Assessment of existing Soil and water conservation practices in Mizoram

The assessment of soil and water conservation practices in Mizoram was conducted through a multifaceted approach. Primary data was collected from the District Project Management Unit (DPMU), focusing on the implementation status of soil and water conservation practices. Random field visits were undertaken in specific districts to evaluate various aspects such as physical properties, technical functionalities of structures, actual water holding capacity, estimated groundwater recharge, and the overall impact of these structures. In addition, the beneficiary engagement was prioritized, with discussions held to gather their perspectives on the implemented conservation measures and their effectiveness.



To ensure comprehensive verification and validation of the collected data, the expert team consulted with relevant government departments. These included the Land Resources, Soil & Water Conservation Department, Department of Agriculture, Department of Horticulture, Mizoram Remote Sensing Application Centre, and the Department of Science & Technology, Government of India.

For understanding the current water and soil conservation practices in Mizoram, aligned with the objectives of the FOCUS project, encompasses various steps to comprehensively analyze the geographical natural resources and existing practices.

Step 4: Primary field visit and stakeholder meeting

The field visits were conducted by the experts in two phases. Initially, during the inception stage, the expert team visited Serchhip district to consult on project activities and assess all intervention areas under the project. The district team accompanied the experts, engaging in detailed discussions regarding the nature of activities, site selection approaches, and technical parameters for infrastructure. Key water conservation activities in the project area encompassed a variety of initiatives customized to the specific requirements and conditions of each Farmer Interest Group (FIG). These endeavors aimed not only to conserve water but also to enhance agricultural productivity, promote sustainable practices, and bolster community resilience in response to environmental challenges.

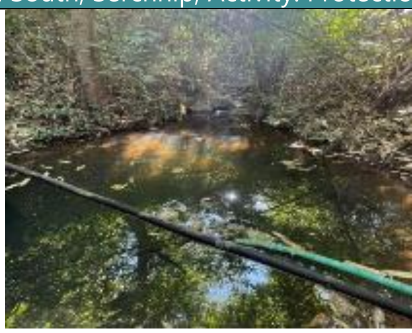
- Low-Cost Bunds
- Nursery Establishments
- Protection of water sources
- Water storage and Delivery system
- Bench Terrace
- Water Harvesting Structure

During the field visits, the experts analyzed the physical properties and technical functionalities of structures, assessed actual water holding capacity, estimated groundwater recharge, and evaluated the overall impact of these structures. Additionally, interactions with beneficiaries and stakeholder consultations were conducted near project sites. These engagements provided valuable insights into the effectiveness of the interventions, allowing for a comprehensive understanding of their impact on water conservation, agricultural productivity, and community resilience.

Expert site visit at Serchhip District

Location: Lumtui Lui, Serchhip, Activity: Diversion Wier under Water storage. & Delivery System (WRC/TRC)

Location: Kanghmun South, Serchhip, Activity: Protection of water sources,



Location: Nunmawia Zau, Zawlpui, Serchhip, Activity : Elevated Water Tank under Landless

The project team initially collected primary data from the department, followed by a second field visit to Kolashib district. During this visit, experts examined various soil conservation practices in the district, including the protection of water sources, water storage and delivery systems, bench terracing, and water harvesting structures. Similar activities have been implemented across all project districts. These field visits allowed for firsthand observation and assessment of the effectiveness of soil conservation measures, ensuring a thorough understanding of their implementation and impact across different regions.

Location: Kolashib, Mizoram

Following extensive field visits and analysis of field data, the team presented the key findings to the FOCUS officials. Additionally, they demonstrated the potential savings and impact achievable through the proposed infrastructure.

Step 5: Impact Assessment & data analysis on soil and water conservation activities

The soil and water conservation activities has been assessed though **OECD** parameters and compare the output with the baseline figures. The major activities such as bunds, check dams, bench terraces, contour tranches and half-moon terraces on rain water runoff. The impact has been assessed based on the OECD parameter such as relevance, coherence, effectiveness, efficiency, impact and sustainability related to soil and water conservation activities, however the major component of the project is to improve Agriculture Resilience and productivity and Value Chain and market access. The technical assessment has been derived using considering the agro ecological condition of the state. The agro ecology condition has two main factors i.e primary and secondary.

Primary factors:

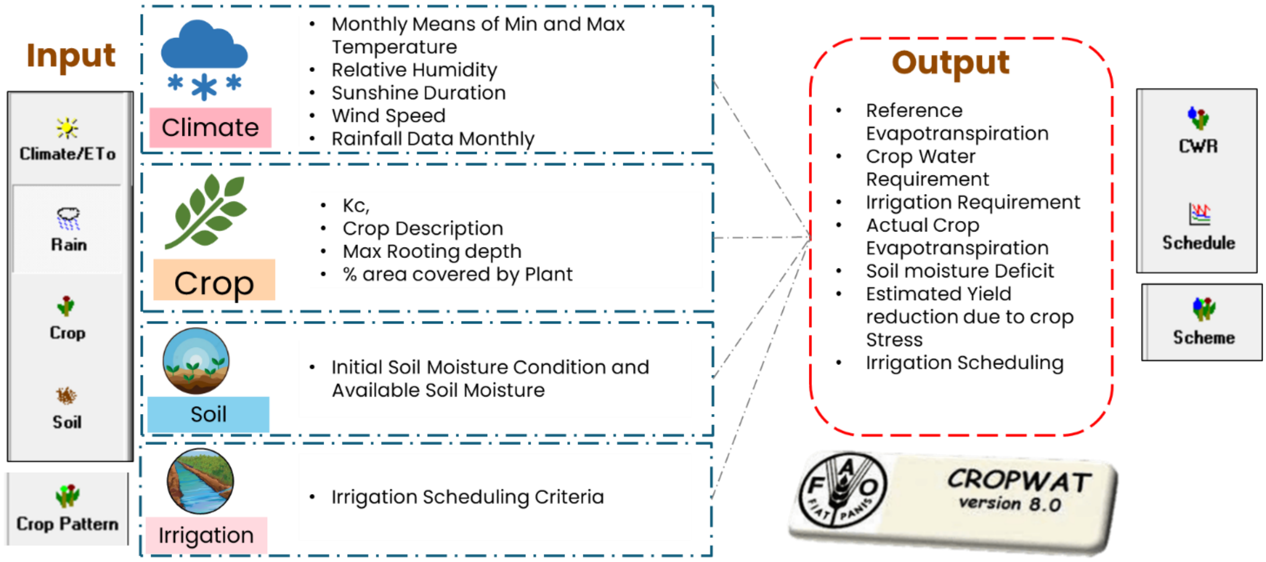
- Soil Types – Type of soil and composition, soil profile, Moisture content, soil temperature, Mineral Nutrients, Soil fertility, pH value etc.
- Temperature – Seasonal variation, day and night, heat wave, evapotranspiration rates, etc.
- Water Availability – Rainfall, Canal, Ground water, etc.

Secondary factors:

- Geological formation- Topography, Altitude
- Cropping Pattern- Land use patterns, primary agricultural crops, horticulture, NTFPs, etc.
- Livestock
- Irrigation & Mineral Resources

It has been observed that paddy is the predominant crop in the project area and is highly dependent on water. Due to its high-water demand, an assessment of water requirements for paddy cultivation was conducted using **CROPWAT 8.0 software**. This facilitated the determination of precise water needs during the paddy season within the project area.

Figure 5: CROPWAT 8.0 Software



Step 6: Recommendation and future roadmap

After identifying the impact and gaps, potential improvements and recommendations are provided, accompanied by a future roadmap spanning short, medium, and long terms. This comprehensive approach not only enhances project sustainability but also establishes a framework for similar projects in the state.

Chapter 3
Existing Resource Assessment

3.1 Agriculture and Horticulture crop Assessment

3.1.1 Existing production of project districts

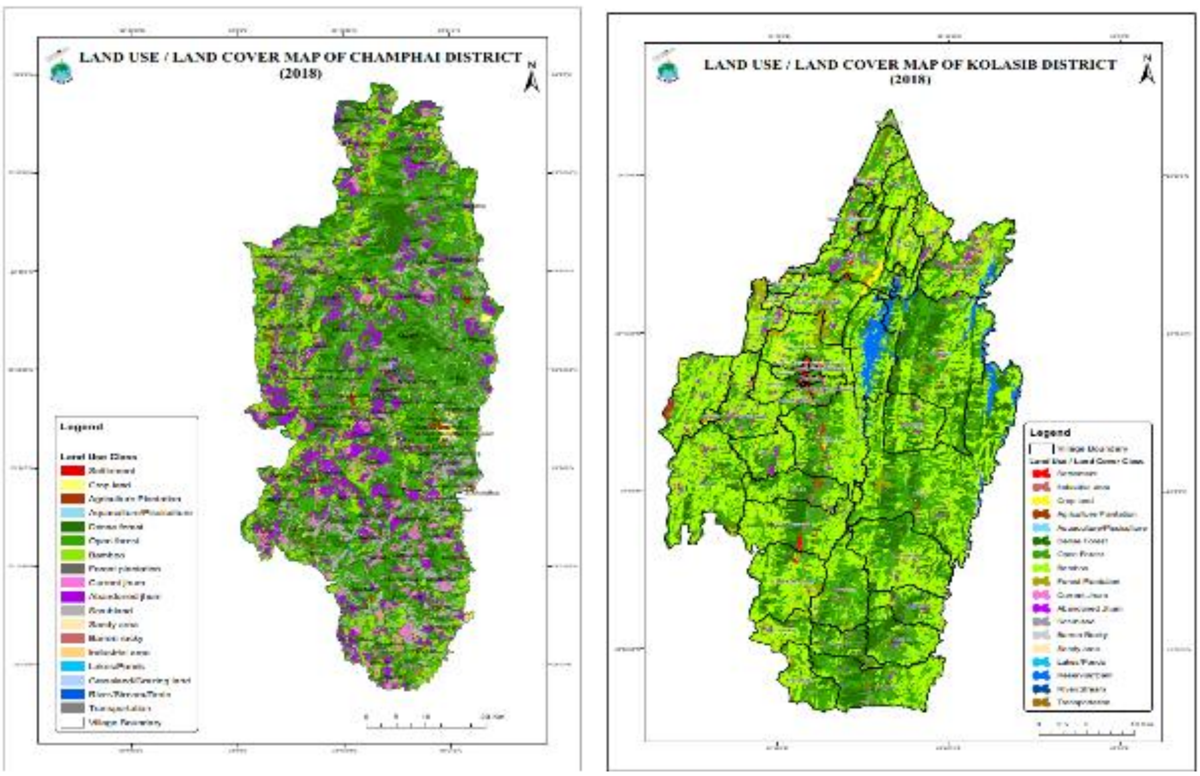
Agriculture holds a pivotal role in Mizoram's economy, with approximately 60% of the workforce involved in the agricultural and related sectors, according to the 2001 census. Paddy cultivation serves as the primary food crop and staple diet for the people of Mizoram. Jhum cultivation dominates the agricultural landscape in the state, with approximately 20,000 hectares cleared and burned annually. Typically, lands under jhum cultivation are used for just one year. Primary crops include upland rice along with maize, pulses, and vegetables. A standard jhum cycle spans 8-10 years, utilizing about 14% of the state's land for this form of cultivation. The land use and land cover area shown the predominant status of agriculture-based livelihood.

Land Use and Land cover

Champhai district boasts a richly varied landscape and a favorable climate, ideal for cultivating a diverse range of horticultural and agricultural crops. Predominantly, paddy cultivation dominates the agricultural scene, thriving in the district's valleys and terraced slopes. Additionally, the agricultural palette includes rice bean, french bean, black gram, mustard, cabbage, cauliflower, potatoes, carrots, soybean, sesame, turmeric, ginger, chillies, and sugarcane. According to data from KVK Champhai District, the district spans a net sown area of 22,059 hectares with a cropping intensity of 120%.

In Kolasib district, the total cultivated area spans 13,398 hectares. The agricultural landscape features a combination of terraced cultivation, Wet Rice Cultivation (WRC), and traditional jhum (shifting cultivation) methods, involving the burning of tracts for mixed crop planting. Noteworthy crops grown include paddy, maize, mustard, sugarcane, oil palm, ginger, sesame, and potato. Efforts are underway to enhance crop productivity through the development of small-scale irrigation projects. Unlike regions with heavy industrial presence, Kolasib district lacks major industrial facilities. However, it sustains a vibrant array of small-scale industries encompassing sericulture, handloom and handicrafts, sawmills and furniture workshops, oil refining, grain milling, and ginger processing.

Figure 6: Land use and Land Cover map of Champhai and Kolasib district



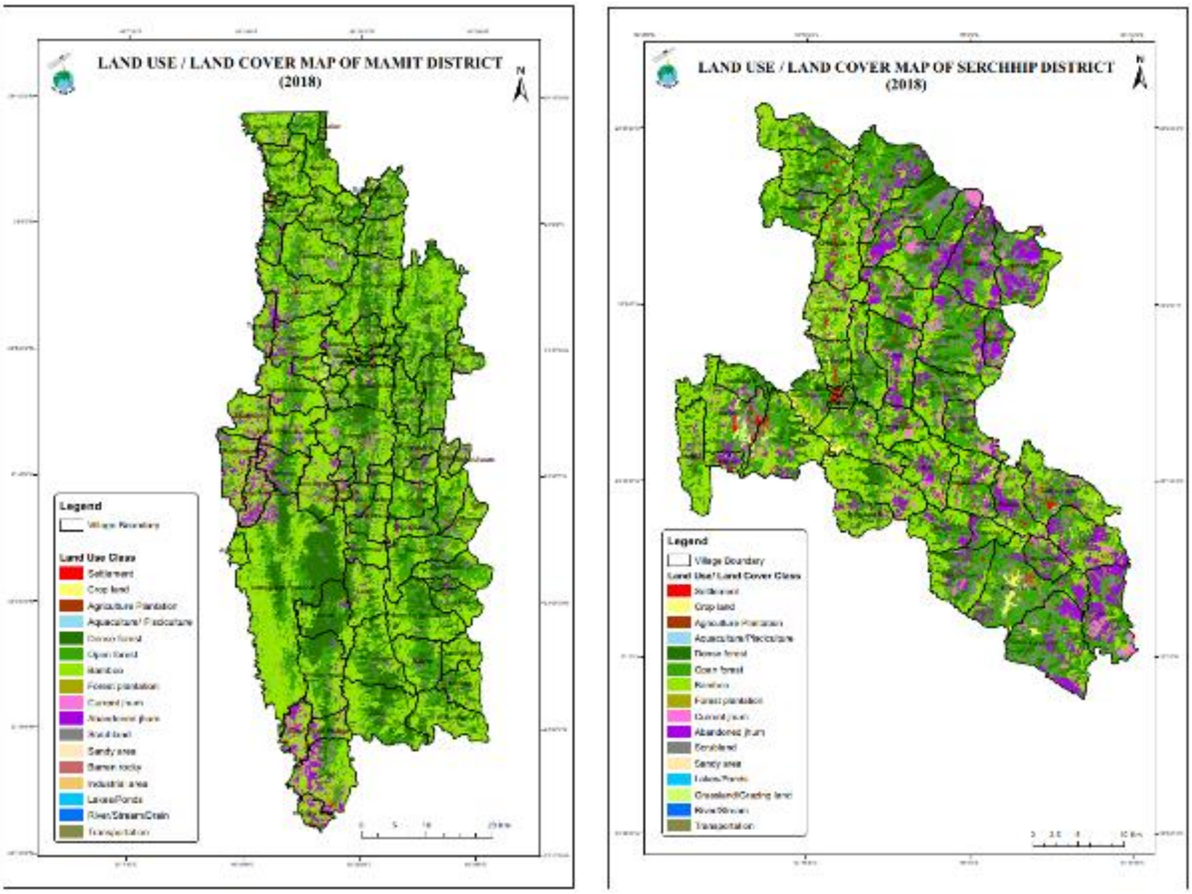
Source: Mizoram Remote Sensing Application Centre

In Mamit district, agricultural land encompasses areas permanently designated for crop cultivation. This category of land is further categorized into Kharif crop land and Agricultural/Horticultural Plantation. While Rabi crops are cultivated in scattered small areas, they are not classified separately due to mapping challenges arising from scale factors. The farming practices in the region include terraced cultivation, Wet Rice Cultivation (WRC), and traditional jhum (shifting cultivation), involving the clearance of tracts by burning and planting mixed crops.

Kharif crop land primarily comprises wetland rice cultivation areas in low-lying plains, influenced by the terrain. Predominantly situated in the northern district, these areas often line rivers, streams, and settlements, benefiting from suitable soil and water conditions. Additionally, the district hosts various agricultural/horticultural plantations, notably oil palm, arecanut, citrus woodlands, and banana plantations.

In Serchhip district, the majority of the population is involved in agricultural pursuits. Primarily, Jhum cultivation is practiced, with main crops including rice intercropped with maize, vegetables, chillies, ginger, turmeric, soybean, etc. Additionally, horticultural crops such as mandarin orange, pineapple, Assam lemon, hatkora, coffee, banana, mango, and papaya are also cultivated.

Figure 7: Land use and Land cover map of Mamit and Serchhip district



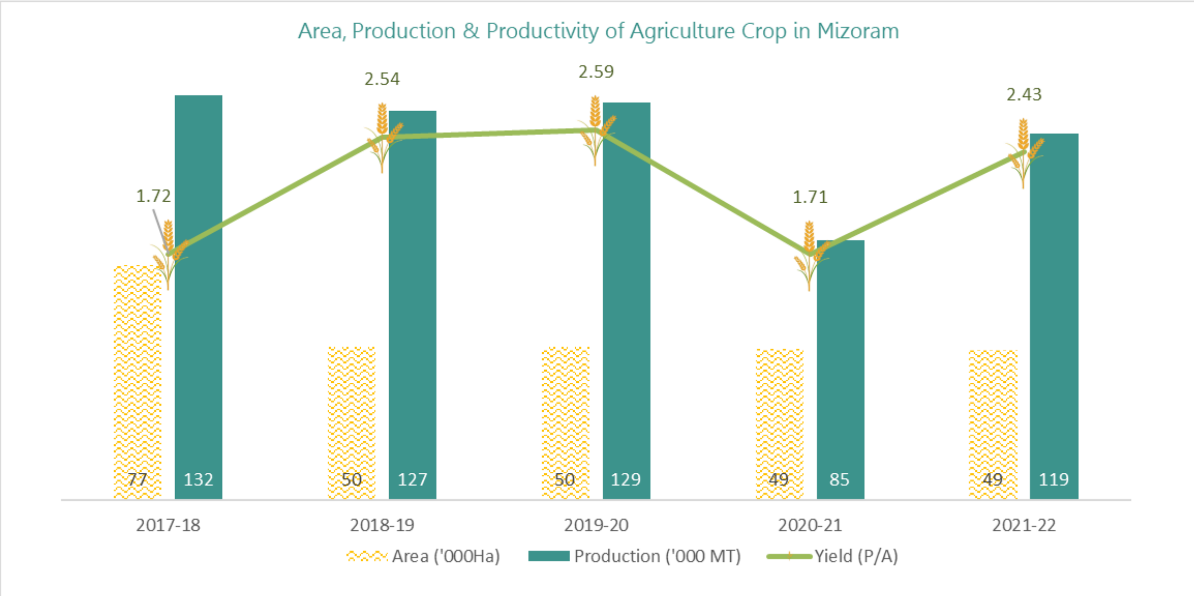
Source: Mizoram Remote Sensing Application Centre

Agriculture crops

Analysis of Mizoram's production data over the last five years reveals a notable trend of increasing productivity in agricultural crops from 2017-18 to 2021-22. However, a dip in productivity was observed in 2020-21, attributed to the impact of the COVID-19 pandemic. Among the prominent crops cultivated in Mizoram are rice, maize, pulses, oilseeds, oil palm, and sugarcane. Throughout this period, efforts to enhance agricultural productivity have been evident, resulting in overall positive growth. This trajectory underscores the resilience of Mizoram's agricultural sector, despite facing challenges such as the pandemic-induced disruptions.

Rice stands out as a staple crop, reflecting its significance in Mizoram's agricultural landscape. Additionally, maize, pulses, oilseeds, oil palm, and sugarcane contribute significantly to the state's agricultural output, catering to both subsistence and commercial needs. Moving forward, continued focus on agricultural development and resilience-building measures will be essential to sustain and further enhance productivity. Moreover, strategies to mitigate the impact of external shocks, such as pandemics or extreme weather events, will be crucial for ensuring the stability and growth of Mizoram's agricultural sector in the future.

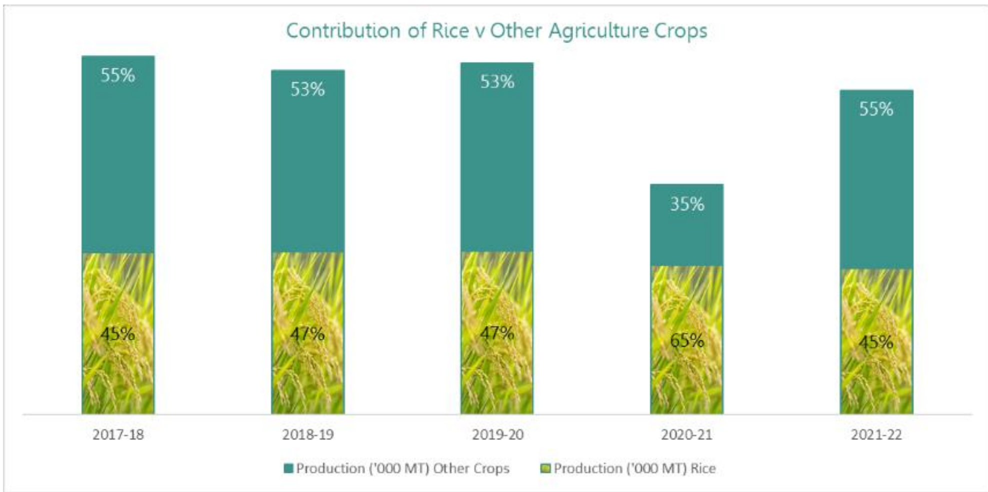
Figure 8: Area, Production & Productivity of Agriculture Crops in Mizoram (2017-22)



Source: Mizoram Statistical Database, Directorate of Economics & Statistics, Government of Mizoram

Rice emerges as key crop in Mizoram, emphasizing the need to assess its contribution to overall agricultural output. The graph below illustrates that rice consistently constitutes around 45 to 47% of the total agricultural production, with a notable increase to approximately 65% in 2020. Similarly, in the project districts, rice maintains a prominent share of the overall agricultural yield. This data underscores the pivotal role of rice cultivation in Mizoram's agricultural sector and highlights its consistent contribution to the state's agricultural productivity. Understanding the dynamics of rice production is crucial for effective agricultural planning and resource allocation, ensuring sustainable development and food security in Mizoram.

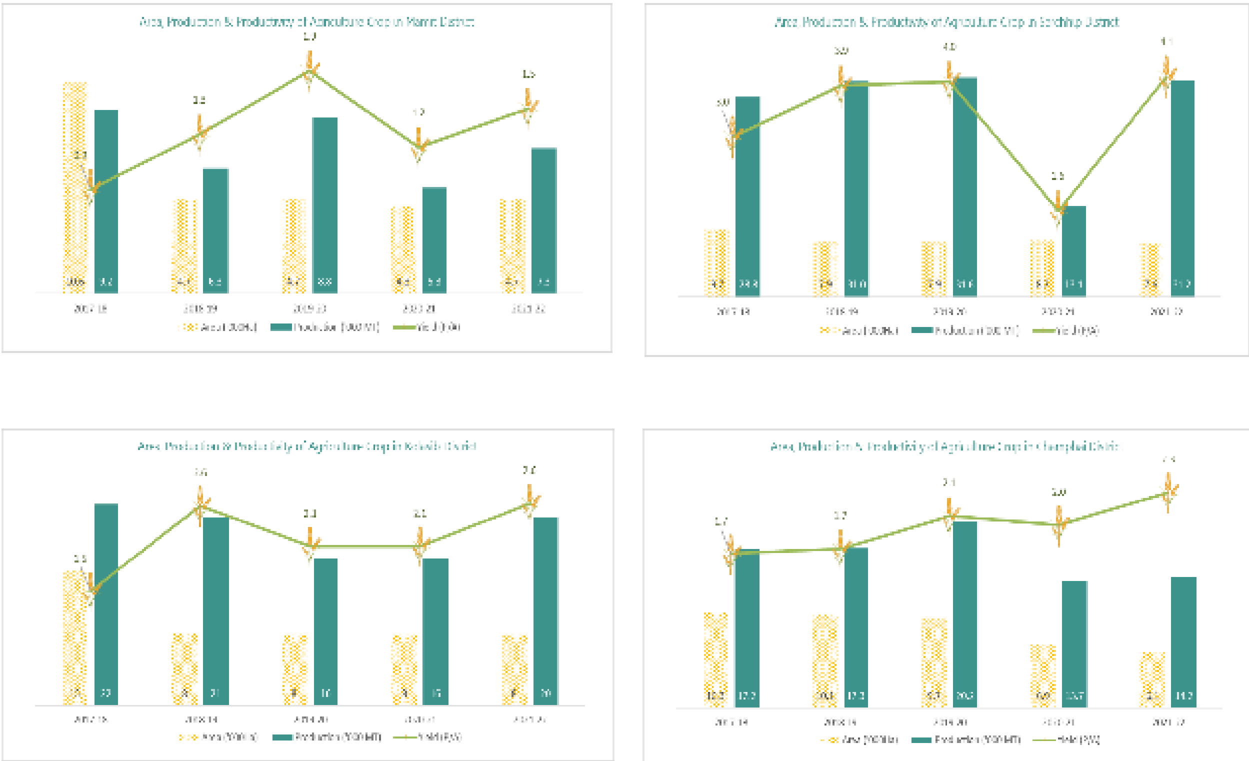
Figure 9: Contribution of Rice v Other Agriculture Crops

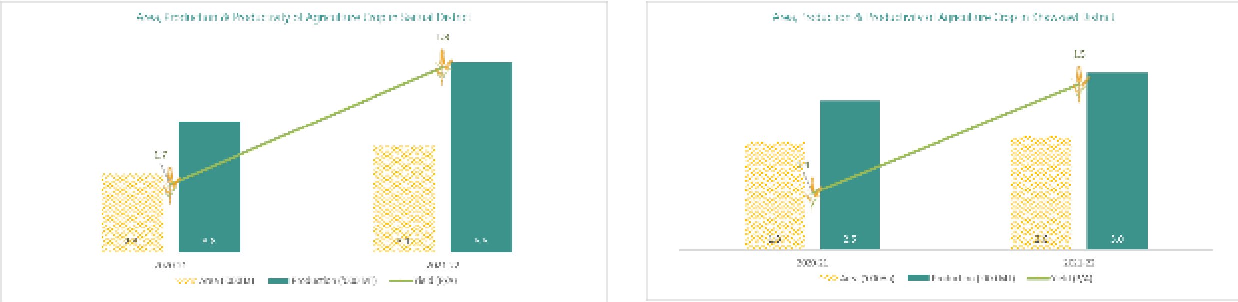


Source: Mizoram Statistical Database, Directorate of Economics & Statistics, Government of Mizoram

The district wise area and production of Agriculture crops are presented in the diagram below:

Figure 10: Area, production and productivity of Agriculture crop in project district

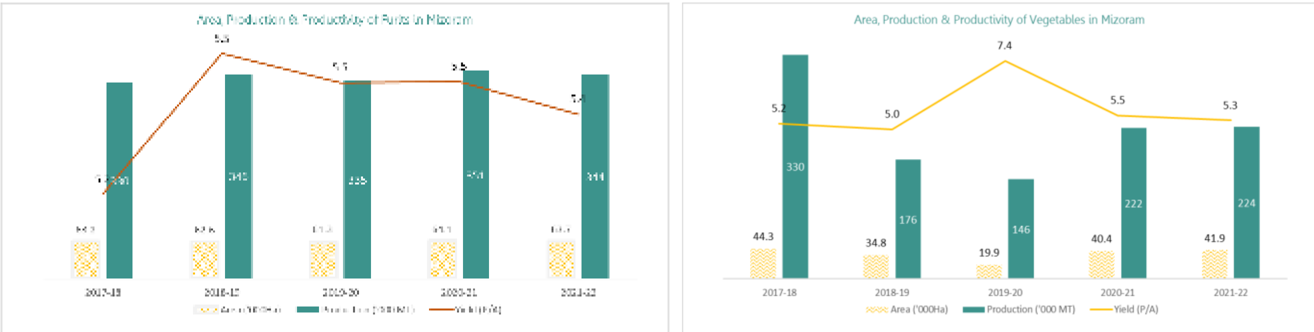




Source: Mizoram Statistical Database, Directorate of Economics & Statistics, Government Of Mizoram

Horticulture Crops

Figure 11: Area, production and productivity of Horticulture crop in Mizoram



Source: Mizoram Statistical Database, Directorate of Economics & Statistics, Government of Mizoram

3.1.2 Project Interventions and beneficiaries

As the Project area has covered more than 300 villages across six districts namely Champhai, Kolasib, Serchhip, Mamit, Saitual, and Khawzawl and the districts collectively represent 42.75% of the state's total geographical area. In Mizoram about 60% of the people are engaged in agriculture with jhum being the main land use and 20,000 ha are being cleared each year for jhum cultivation. Rice is the main staple food, and upland paddy is the main jhum crop, grown mixed with other crops.

One of the focal points of attention is the enhancement of jhum management due to its widely acknowledged negative impacts on the environment and sustainability. Jhum, often considered a destructive farming practice, is associated with significant soil erosion, atmospheric pollution, depletion of soil biology, and loss of biodiversity. The system's sustainability is increasingly compromised as jhum cycles shorten, allowing less time for the restoration of soil fertility and biodiversity. Moreover, jhum cultivation is labor-intensive, lacking potential for mechanization, with women typically bearing the brunt of the workload. Despite significant effort, the low crop yields result in minimal productivity per day worked, often failing to meet household food requirements or provide essential cash income.

To address the above issue related to jhum management, the FOCUS project has implemented various interventions aimed at not only addressing these issues but also enhancing market access and developing value chains. Through the project, jhumia households have been supported in transitioning to alternative farming systems, notably sedentary farming. This approach has facilitated the cultivation of more productive wet rice fields, enhanced plantation crops, improved livestock systems, and boosted off-farm income opportunities.

In addition, for settled agriculture, the FOCUS project has implemented various interventions aimed at enhancing productivity. These include promoting existing rice cultivation on lowlands by introducing short-duration seeds and employing fertility improvement techniques to optimize yields. Additionally, efforts have been made to improve cropping intensity. Moreover, the project has focused on existing orchards and plantations by demonstrating soil and water conservation techniques, providing improved planting materials, and encouraging the cultivation of high-value trees to maximize returns. In Mizoram, the poorest households in each village have been supported to get access to land for settled agriculture. The project was target to get support 15,190 ha of existing terrace cultivation, 15,190 ha of upland settled agriculture and 2,720 ha of settled agriculture to landless.

Under FOCUS, Mizoram Remote Sensing Application Centre (MiRSAC) has prepared land use maps and land suitability maps for two districts. Based on the land use maps and also land suitability classification maps, Village Councils and Site Allotment Advisory Boards (SAAB) has been trained to identify lands suitable for growing various crops based on the slope, altitude and soil texture, and to allocate land based on this scientific information for jhum, settled agriculture and village forest conservation, fix boundaries for land allocated for settled agriculture and Decide on the crops to be cultivated to ensure development of economies of scale required for accessing markets.

3.1.3 Identification of indigenous crop in project area

As part of the FOCUS project, Mizoram University has been tasked with identifying indigenous crops through thorough field investigations utilizing scientific methods. Among the documented crops are Bird Eye Chilli, known locally as Mizo Chilli, along with 'Puakzo', 'Siata Vaimim', and 'Chhipui'. 'Puakzo' and 'Siata Vaimim' represent varieties of maize, while 'Chhipui' is a type of Sesame crop. These four crops are native to Mizoram. This initiative aims to preserve and promote indigenous agricultural biodiversity, fostering sustainable farming practices and supporting local livelihoods. Through scientific research and documentation, Mizoram University plays a vital role in recognizing and conserving the rich cultural heritage and agricultural heritage of Mizoram.

Figure 12 Indigenous crop in project area

Bird Eye Chilli	Puakzo
	
Chhipui	Siata Vaimim
	

Mizo Chilli, also known as Bird Eye Chilli, stands out as the primary crop cultivated by farmers, while the cultivation of the other three documented crops is scarce, sporadic, and declining. These crops are clearly part of a traditional farming practice passed down through generations. Although pinpointing a precise timeline is challenging, all sources suggest that these crops have roots in the migration from the Chin Hills in present-day Myanmar to Mizoram during the late 16th to 17th century AD.

3.2 Soil assessment

Mizoram, located in Northeast India, boasts a diverse array of topography and climates that favor the cultivation of a wide range of crops. The state's landscape features hills, valleys, plateaus, and plains, each contributing to the diverse soil types found in Mizoram. The Soil and Land use Survey of India identifies six primary soil types in the region: red soil, laterite soil, alluvial soil, mountain soil, peat soil, and clay soil. Understanding the properties and characteristics of each type of soil in Mizoram is crucial for farmers to determine suitable crop choices and farming practices that can maximize yields while preserving natural resources.

Red Soil	Laterite Soil	Alluvial Soil
Mountain Soil	Peat Soil	Clay Soil

3.2.1 Types of Soil in Mizoram and its characteristics

Each type of soil has its own unique properties and characteristics that make it suitable for certain types of crops and land use practices. Agricultural practices on alluvial soil require careful management to prevent erosion, while farming on mountain soil presents challenges due to steep slopes and shallow soil depth. Sustainable land management practices can help improve soil quality and enhance agricultural productivity while preserving natural resources for future generations.

Red Soil

The characteristics and properties of red soil in Mizoram are noteworthy due to their distinct features and potential for agricultural productivity. Red soil is a type of lateritic soil that is formed by the weathering of igneous rocks such as granite, gneiss, and basalt. Its color ranges from yellowish-red to deep red, due to the presence of iron oxide minerals. The texture of red soil varies from sandy to clayey, with good drainage properties.

Red soil has significant agricultural significance due to its unique properties. It is rich in aluminium, calcium, magnesium, and potassium which make it suitable for growing crops like tea, coffee, rubber, pulses and oilseeds. The good drainage properties prevent waterlogging during monsoon season while retaining moisture during dry spells. As a result, farmers can cultivate crops throughout the year without fear of crop failure.

Laterite soil:

This type of soil has distinctive features that make it suitable for different types of crops grown in the region. Composed of aluminium and iron oxides, laterite soil is a commonly used material for road construction due to its high load-bearing capacity. This type of soil is formed through weathering and leaching processes in tropical regions with high rainfall. Compared to other soil types, laterite soil has relatively low fertility due to its high levels of acidity and nutrient deficiency. However, it can be enriched with organic matter and nutrients to improve its fertility.

Despite its low fertility, laterite soil has many uses beyond road construction. It is often used as a building material for homes and other structures due to its strength and durability. Additionally, it can be mixed with cement or lime to create a stable foundation for buildings. Another important use of laterite soil is in agriculture. Though not naturally fertile, this type of soil can be treated with fertilizers and organic matter to increase crop yield. In some cases, farmers have even used laterite soils for terrace farming in hilly areas where other types of soils are less suitable.

Alluvial Soil

Alluvial soil, formed through the continuous movement of water, is a dynamic type of earth resulting from the deposition of sediments carried by rivers and streams. The process begins with the weathering and erosion of rocks, minerals, and organic matter, which are then transported downstream by flowing water. As these materials accumulate in riverbeds, floodplains, deltas, or estuaries, they settle and form layers of sedimentary deposits over time. Alluvial soils are characterized by their high fertility levels due to their composition which includes a variety of nutrients such as nitrogen, phosphorus, potassium, calcium, and magnesium. These nutrients can sustain various types of plant life including crops like rice paddy fields which are commonly found in Mizoram's low-lying areas where alluvial soil is prevalent.

Mountain Soil

Similar to a challenging puzzle, mountain soil presents several obstacles for crop cultivation due to its steep slopes and shallow depth which can limit water retention and nutrient availability. The terrain of Mizoram is hilly with an altitude ranging from 200 to 2,500 meters above sea level, making mountain agriculture the predominant farming practice in the region. Mountain soil primarily consists of weathered rocks and minerals with varying degrees of organic matter content. Due to the steep incline of these soils, erosion is a common occurrence that leads to loss of topsoil and nutrients. The impact of terrain on soil fertility cannot be overstated when it comes to mountain agriculture in Mizoram.

Soil conservation practices such as terracing have been introduced in the region but are yet to take root among farmers due to high costs associated with their implementation. Additionally, the presence of trees on these soils also affects nutrient uptake by crops grown in them since tree roots compete for available nutrients with crop plants. As a result, farmers must use fertilizers judiciously while adopting appropriate cropping systems that allow for efficient nutrient utilization.

Peat Soil

In Mizoram, peat soil is not as prevalent compared to other types of soil such as alluvial soil. Mizoram's terrain is characterized by hilly and mountainous regions, where peat soil formation is less common due to the absence of extensive wetlands or swamps. However, there may be localized occurrences of peat soil in certain low-lying areas with waterlogged conditions, such as marshy patches or shallow wetlands. These areas may support the development of peat soil over time through the accumulation of organic matter from decaying vegetation. Nonetheless, peat soil is not typically a dominant soil type in Mizoram, and the region's agriculture is primarily based on other soil types like red and laterite soils found in the hilly terrains.

Clay Soil

Clay soil, being one of the most common types of soil, has both advantages and disadvantages when it comes to agricultural productivity. One of the main advantages is its ability to hold water and nutrients well. This makes it ideal for crops that require consistent moisture and nutrient supply, such as rice, wheat, and soybeans. Additionally, clay soils have a high cation exchange capacity (CEC), which means they can retain positively charged ions like calcium, magnesium, and potassium that are essential for plant growth.

However, there are also some disadvantages of using clay soil for farming. One major drawback is its tendency to become compacted easily due to its small particle size and high density. Compacted soil restricts root growth and reduces overall crop yield. Another issue with clay soil is drainage; because it retains water so well, excess water can accumulate in low-lying areas leading to waterlogging or even flooding. This can be detrimental for many crops that do not thrive in excessively wet conditions.

As part of the FOCUS project, an in-depth study was carried out to identify crops suitable for the soil conditions in the project district. This study facilitated an understanding of the land use profile based on soil fertility in the project area, consequently leading to a modest increase in productivity. The tables below outline the most favorable locations for crop cultivation based on soil classification, along with other significant factors.

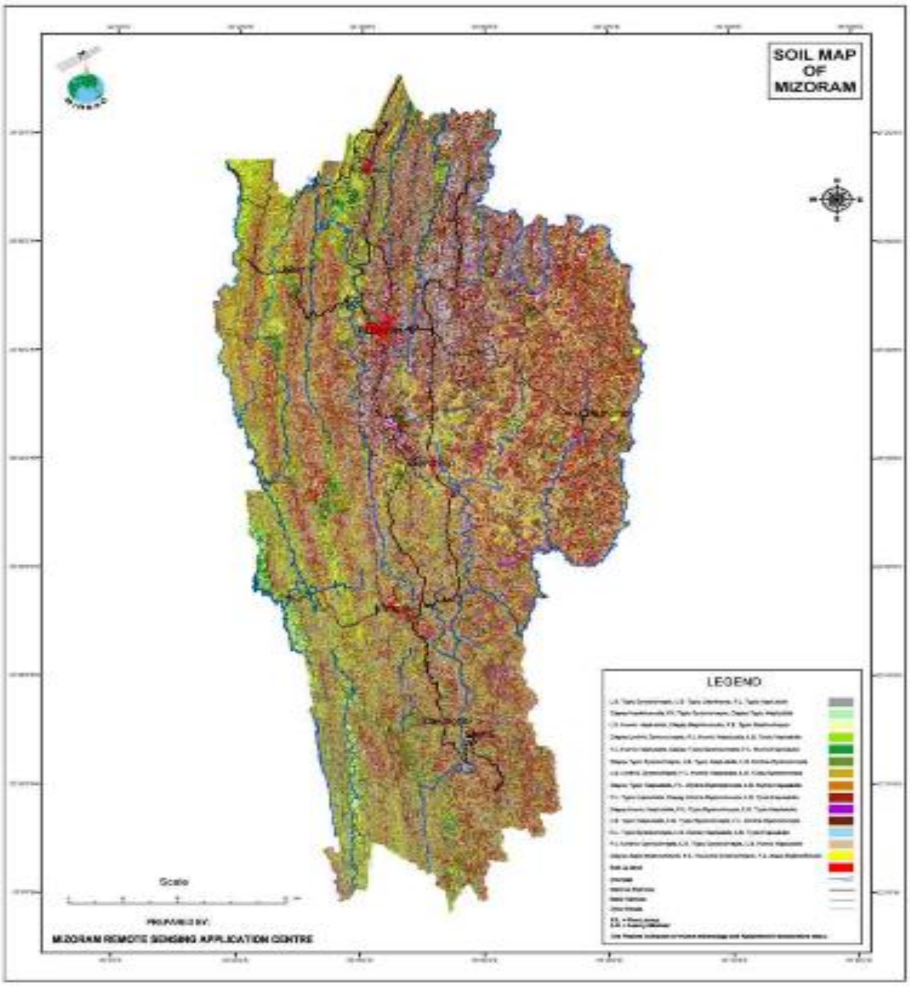
3.2.2 Criteria for Soil Site Suitability Analysis of All Crops

Suitability Degree	Soil pH	Soil Org.C (in %)	Soil EC (dS/m)	Soil Nitrogen Kg/ha	Soil Phosphorus Kg/ha	Soil Potassium Kg/ha
High	6.6 - 6.9	>0.75	<1	>560	>25	>280
Medium	5.6 -6.5	0.5-0.75	1-2	280-560	10-25	120-280
Low	4.6 - 5.5	0.25 - 0.5	2 - 3	140 - 280	5 - 10	60 - 120
Not Suitable	<4 or >7	<0.25	>3	<140	<5	<60

Source: MIRSAC, Aizawl, Mizoram

The soils of Mizoram are dominated by sedimentary formation. The soil in the hills is strongly acidic in reaction, whereas, the soils in alluvial deposits are less acidic in nature. The surface soils of the hilly terrains are dark, highly leached and poor in bases, rich in iron and have pH values ranging from 4.5 to 6.9 (highly acidic). They are well drained, deep to very deep, rich in organic carbon, low in available phosphorus content and high in available potash. The surface soil textures are loam to clay loam with clay content increasing with depth. The percentages of clay, silt and sand within 50cm of the surface in most cases are 20-30% and 25-45% respectively. The pH and organic carbon contents decrease and clay increases with depth. The base saturation above a lithic or paralithic contact is mostly low (below 35%). They are capable of providing substantial oxygen supply for plant growth and have capability to retain moisture and maintain supply through the growing seasons of most crops. Soils of the valley flat lands are brown to dark brown, poor in bases, moderately acidic with pH ranging from 5.5 to 6.0, medium to high in organic carbon content, low available phosphate and medium to high available potash. These are deep to very deep but moderately to poorly drained. The texture of the soil is mostly sandy loam to sandy clay loam. The percentage of clay, silt and sand in the upper 50cm ranges 15-35% 5-34% and 40-75% respectively. Clay contents do not increase with depth. The district wise soil classification is presented in the diagram below across the Mizoram.

Figure 13: Soil classification map of Mizoram



Landscape and Climate Suitability class index for Rice

Suitability class	Slope (in %)	Altitude (in m)	Aspect	Rainfall (in mm)	Temperature (in °C)
Highly Suitable	0-50	50 - 1000	South, South-East	1000 - 1500	15 - 20
Moderately Suitable	50-60	1000 - 1500	East, South-West	1500 - 2000	20 - 30
Marginally Suitable	60-80	1500 - 2000	West, North-West	2000 - 3000	30 - 37
Not Suitable	>80	>2000	North, North-East	>3000	<15 or >37

Source: MIRSAC, Aizawl, Mizoram

Landscape and Climate Suitability Criteria for Mizo Chilly

Suitability class	Slope (in %)	Altitude (in m)	Aspect	Rainfall (in mm)	Temperature (in °C)
Highly Suitable	0-50	100 - 650	South, South-East	600 - 1500	15 - 20
Moderately Suitable	50-60	650 - 800	East, South-West	1500 - 2000	20 - 30
Marginally Suitable	60-80	800 - 1500	West, North-West	2000 - 2450	30 - 35
Not Suitable	>80	>1500	North, North-East	>2450	<15 or >35

Source: MIRSAC, Aizawl, Mizoram

Landscape and Climate Suitability Criteria for Turmeric and Ginger

Suitability class	Slope (in %)	Altitude (in m)	Aspect	Rainfall (in mm)	Temperature (in °C)
Highly Suitable	0-50	300 - 1000	South, South-East	1500 - 2500	15 - 20
Moderately Suitable	50-60	1000 - 1200	East, South-West	2500 - 3000	20 - 30
Marginally Suitable	60-80	1200 - 1500	West, North-West	3000 - 3200	30 - 35
Not Suitable	>80	>1500	North, North-East	>3200	<15 or >35

Source: MIRSAC, Aizawl, Mizoram

Table 2 : Soil observation of project districts

District	Description
Champhai	The rocks of this area are generally sandstone and shale, the derived soils are mostly red and yellow loamy. The soil is acidic in nature due to heavy rainfall. It contains a high amount of organic carbon and is high in available nitrogen, low in phosphorus and potassium content.
Kolasib	Kolasib district represents a monotonous sequence of argillaceous and arenaceous rocks, which are classified by Geological Survey of India into two formations viz., Middle Bhuban and Upper Bhuban formations. The formations are folded into almost N-S trending anticlines and synclines and affected by longitudinal, oblique and transverse faults of varying magnitudes. The rocks of this area are generally sandstone and shale, the derived soils are mostly red and yellow loamy. The soil is acidic in nature due to heavy rainfall. The soil moisture regime is classified as Udic and temperature regime qualifies for Hyperthermic. Mizoram is uniquely characterized by several prominent hill ridges running parallel to each other, most of which roughly runs from north to south, except the southernmost hill ridges. Few plain areas of small dimensions in between the hills and along the river banks are noticed in certain parts. They are more confined to the northernmost part of the district.
Serchhip	In this district, the main types of rocks are sandstone and shale, which make the soil mostly red and yellow loamy. The soil is acidic because of a lot of rain. It has a good amount of organic carbon and nitrogen but not much phosphorus and potassium. The weather here is warm and humid, which helps these types of soils form. This affects farming because certain crops grow better in this kind of soil and climate.
Mamit	Mamit represents a monotonous sequence of argillaceous and arenaceous rocks, which are classified by Geological Survey of India into two formations viz., Middle Bhuban and Upper Bhuban formations. The formations are folded into almost N-S trending anticlines and synclines and affected by longitudinal, oblique and transverse faults of varying magnitudes. Some authors claimed that the area west of Zamuang up to Kanhmun is represented by Tipam Formations. The area is characterized mainly by three main ridgelines and intervening valleys and less prominent ridges. The rocks of this area are generally sandstone and shale, the derived soils are mostly red and yellow loamy. The soil is acidic in nature due to heavy rainfall. It contains a high amount of organic carbon and is high in available nitrogen, low in phosphorus and potassium content.

Source: MIRSAC, Aizawl, Mizoram

3.3 Water Assessment

This section provides a detailed elaboration on water assessment, focusing on the primary sources of water including rainfall, river systems, and groundwater sources. Each of these sources plays a crucial role in sustaining water availability and usage within the region. The assessment delves into the specific characteristics and dynamics of these water sources, analyzing factors such as rainfall patterns, river flow regimes, and groundwater levels. By examining these aspects in detail, stakeholders gain a comprehensive understanding of the region's water resources and their variability over time. This information is further detailed in the subsequent section, which provides a thorough description and analysis of the assessment findings, offering insights into water availability, usage patterns, and potential challenges or opportunities for water management and conservation efforts.

3.3.1 Rainfall

Mizoram, influenced directly by the South-West Monsoon, typically experiences ample rainfall throughout the year. The rainy season, spanning from April to late October, sees heavy precipitation, with May to September being particularly abundant. Conversely, the winter months from November to February are generally dry with minimal rainfall.

Mizoram utilized 45 rainfall collecting stations throughout 2021 to gather data on precipitation. These stations are strategically located across the region to provide comprehensive coverage of rainfall distribution.

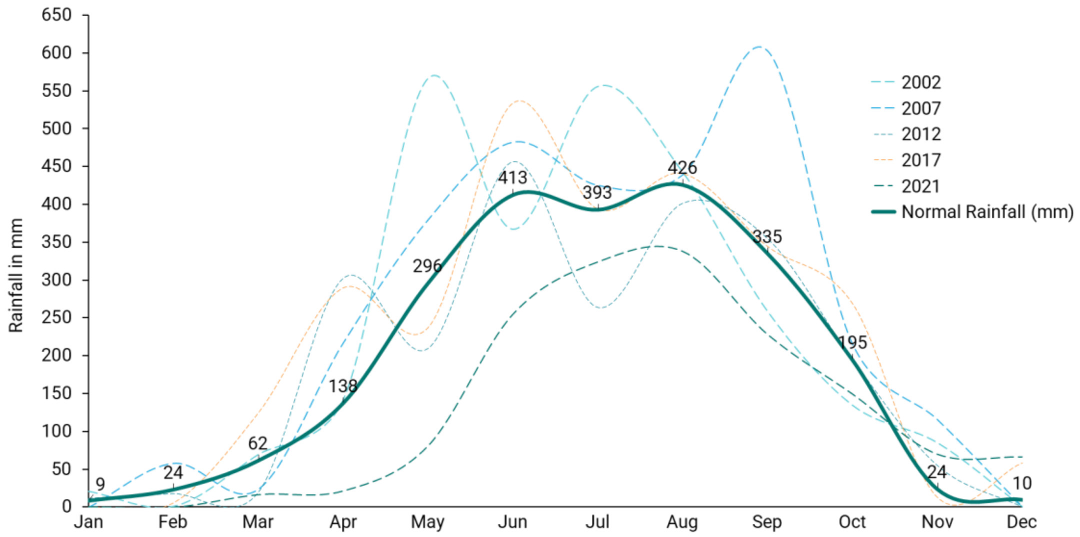
Table 3 : Weather station in Mizoram

S. N	District	Stations
1	Mamit	6
2	Kolasib	5
3	Aizawl	10
4	Champhai	3
5	Serchhip	4
6	Lunglei	5
7	Lawngtlai	3
8	Siaha	2
9	Saitual	1
10	Hnahthial	3
11	Khawzawl	3
Total		**45**

(Source: Directorate of Economics & Statistics, Government of Mizoram.)

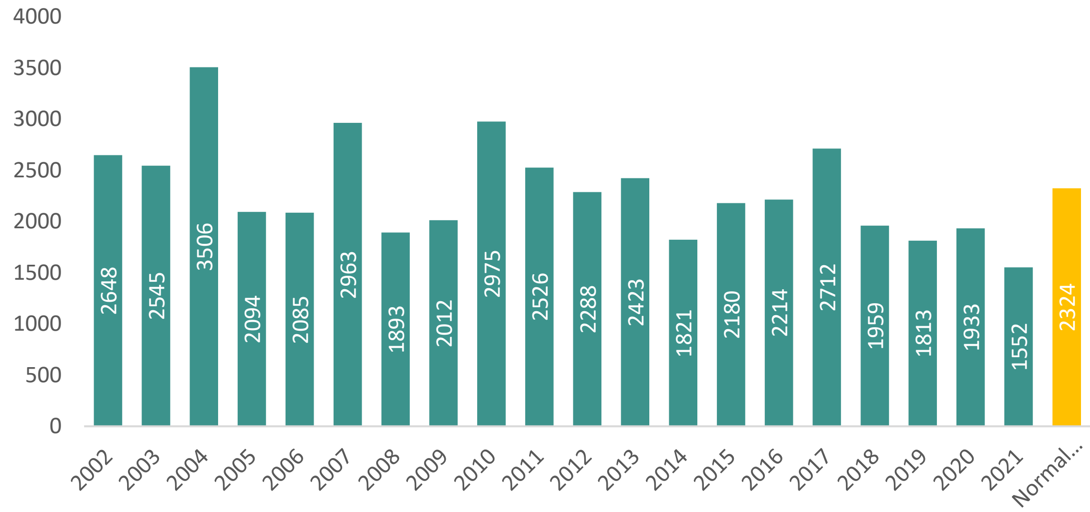
The table shows the amount of rainfall each month and every year from 2002 to 2021. It includes the average rainfall expected for each month and the total rainfall for the whole year. Each year shows significant variation in rainfall patterns. Notably, 2021 had the lowest annual rainfall (1551.6 mm), with particularly dry months in January (0.7 mm) and February (0 mm). In difference, 2017 recorded a substantial annual total of 2712.3 mm, with significant rainfall during July (394.2 mm) and August (441 mm). Years like 2010 and 2004 stand out for having extremely high annual totals of 2974.9 mm and 3506.1 mm respectively, due to very wet months like May (464.2 mm) in 2010 and July (850.8 mm) in 2004. The normal rainfall provides a benchmark, showing expected monthly averages such as 412.7 mm in June and 426 mm in August, against which these yearly variations can be compared. This data reflects a clear trend of fluctuating rainfall, suggesting potential climate variability impacting the region over the past two decades.

Figure 14: Monthly Rainfall data of Mizoram (2002-2021)



Source: Directorate of Economics & Statistics, Planning & Programme Implementation Department, Government of Mizoram

Figure 15: Annual Rainfall data of Mizoram (2002-2021)

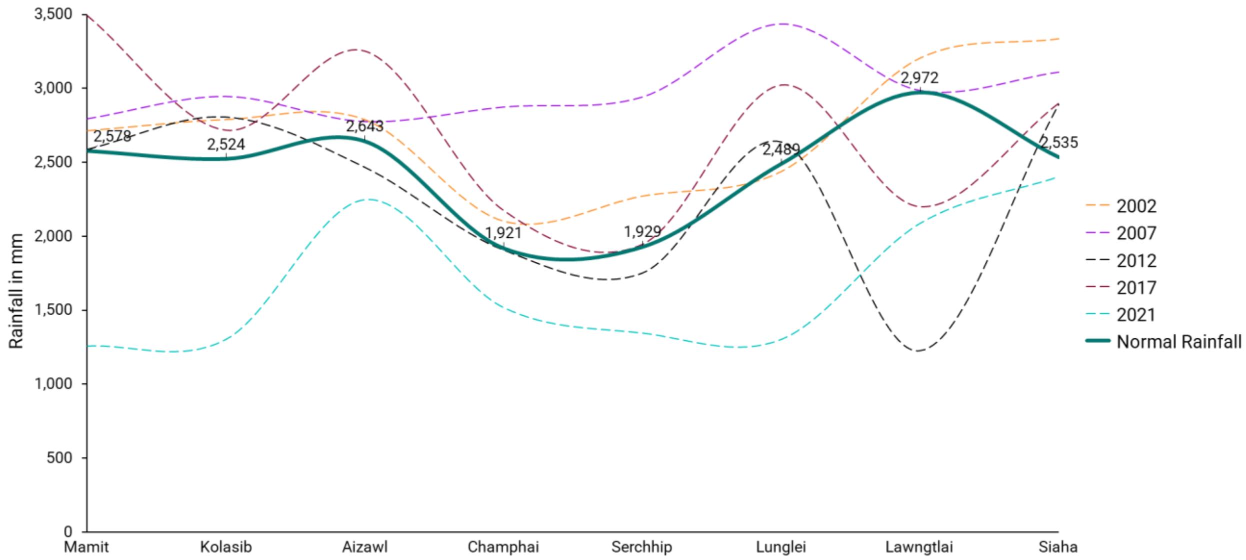


Source: Directorate of Economics & Statistics, Government of Mizoram

District-wise Rainfall Distribution:

The below figure provides annual rainfall data (in mm) for the years 2002, 2007, 2012, 2017, and 2021 across eight districts in Mizoram: Mamit, Kolasib, Aizawl, Champhai, Serchhip, Lunglei, Lawngtlai, and Siaha, with normal rainfall values serving as a benchmark. The other district such as Saitual, Hnahthial and Khawzawl has no historical data as these districts separated in 2020 year. The data highlights significant fluctuations in rainfall over the years, with 2021 notably experiencing the lowest rainfall across all districts compared to previous years and historical averages. For instance, Mamit recorded a dramatic drop to 1258.3 mm in 2021 from a high of 3493.1 mm in 2017, and similarly, Lunglei dropped to 1302.5 mm in 2021 from 3435.5 mm in 2007. These variations suggest a trend towards increasing climate variability and potential shifts in rainfall patterns, underscoring the importance of adaptive measures in water resource management and planning. The overall trend in 2021, with all districts recording significantly lower rainfall than the historical norms, indicates a particularly dry year and raises concerns about the impacts on agriculture, water supply, and local ecosystems. District-Wise Annual Rainfall in Mizoram (In mm) for the last 20 Years (2002-2021) are provided in the below figure:

Figure 16: District wise annual rainfall data of Mizoram (2002-2021)



Source: Directorate of Economics & Statistics, Government of Mizoram

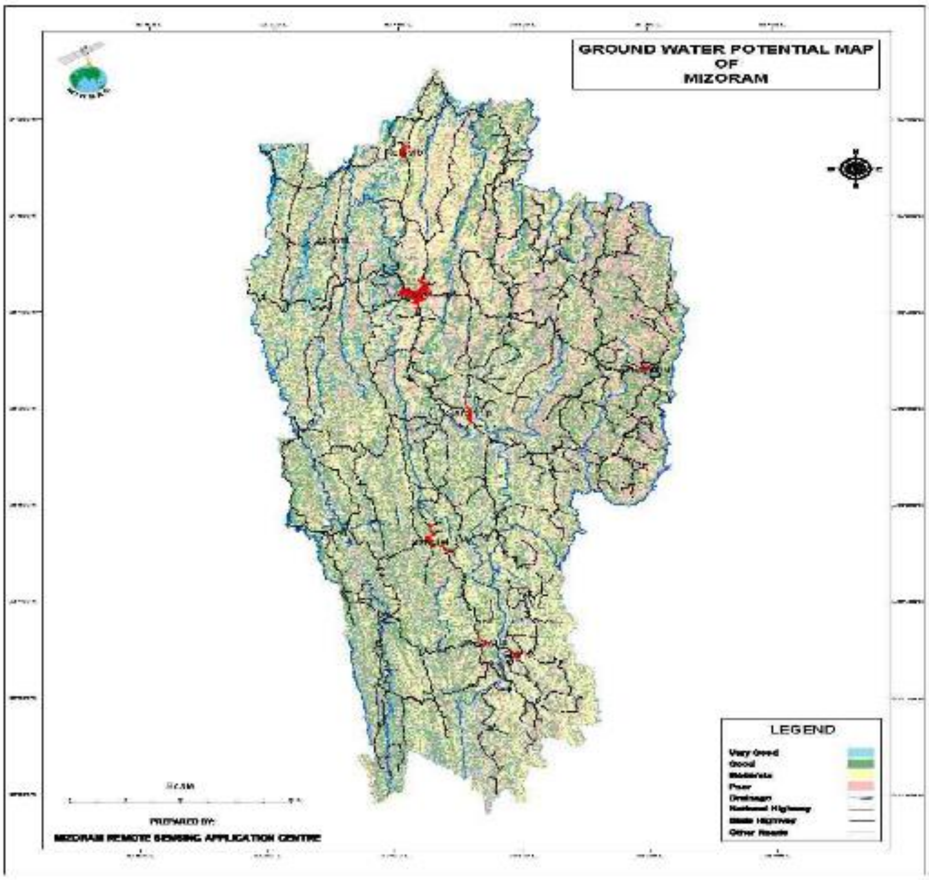
3.3.2 Ground water

Water is essential for life, and in Mizoram, it primarily comes from rain, which varies depending on the season. This rain fills up springs, rivers, lakes, ponds, reservoirs, and seeps into the ground. Changes in the landscape, population, land use, and yearly rainfall patterns affect water availability in the state. It's crucial to manage this water system sustainably, considering Mizoram's development goals. This includes understanding the geography, surface and groundwater status, priorities for water use, and other specific needs. By carefully managing these factors, Mizoram can ensure a reliable and sufficient water supply to meet its growing demands while preserving its natural resources for future generations.

90% of the annual precipitation in Mizoram falls between March and September, and 72% of the annual rainfall in the State occurs between the months of June and September. There is scanty rainfall in the winter months, leading to water scarcity issues in certain pockets. Analysis of IMD regional precipitation data for a 115-year period for Nagaland, Manipur, Mizoram and Tripura (NMM), considered as a combined region in the IMD data set, presents a declining trend. The decline is of the order of 3.94 mm/year at a 99% confidence level. Figure presents the annual trends of precipitation between 1901 and 2015. The observed decline is significantly steeper for the latest 50 years spanning the period 1965-2015 (11.32 mm/year) as compared to 63 years (8 mm/year) of observation since 1901.

In Mizoram, the hilly topography and soil properties contribute to poor groundwater retention. Groundwater potential is classified as poor to moderate in 72% of the state's area. Consequently, the above-average precipitation in the region does not correspond to high levels of groundwater availability. Despite having a significantly high hydro power potential of 4,500 MW, only 2% of this potential has been tapped. As a result, the state's water storage capacity through reservoirs is low. Given the inter- and intra-annual variations in precipitation-both temporal and spatial-exacerbated by human-induced climate change, along with low groundwater and surface water retention, it is imperative for the state to prepare for changes in water availability.

Mizoram has mild climate which is suitable for cultivation of crops throughout the year. However, due to scarcity of water during dry period crops cannot be grown throughout the year. In many parts of the State, rice can be grown two times in a year but due to scarcity of water during winter season, rice is grown only during Kharif season in many potential areas. Similarly, terraces constructed in many places leading to permanent cultivation in jhum area, cannot be cultivated during dry season because of limited water storage facilities.



(Source: MIRSAC, Mizoram)

According to the 2021 report, by the Central Ground Water Board (CGWB), the groundwater resource assessment in Mizoram indicates that the entire state falls within the safe zone for groundwater categorization. There are no areas where groundwater recharge is considered to be of poor quality.

Resource	Values
The total resources of the state	0.20 BCM
Gross ground water draft (annual)	0.007 BCM
Balance available for future development	0.19 BCM
Stage of development	3.7%
Categorization of assessment units	Safe (all units)
Ground water recharge in Poor quality zone	Nil

Source: CGWB

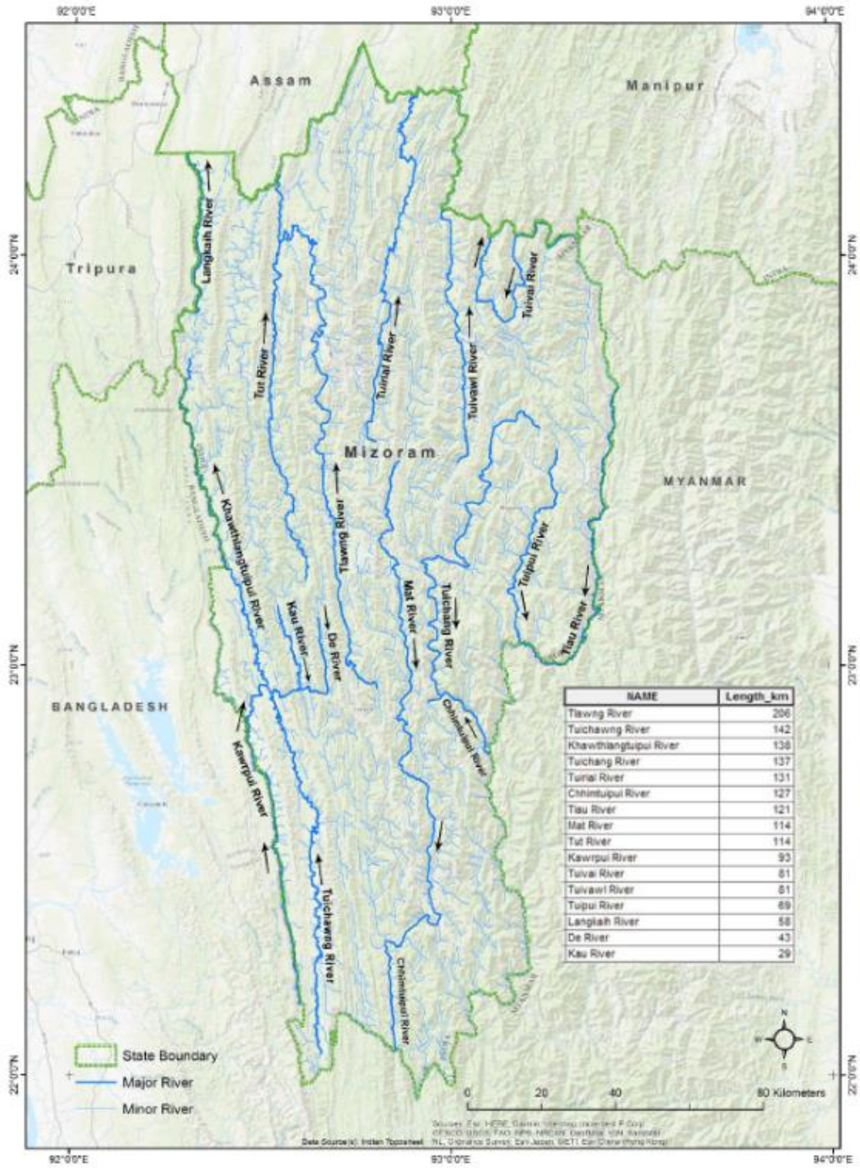
3.3.3 Surface Water

The hydrography of Mizoram directly reflects its drainage and climatic conditions. The state's drainage system consists of three main basins: **Barak** (part of the Ganga-Brahmaputra basin), **Karnaphuli**, and

Kolodyne. Mizoram's hilly terrain is characterized by a dense network of rivers and streams. The state also features several lakes, wetlands, and waterfalls. Based on its physiography, a total of 22 well-defined watersheds have been identified in Mizoram.

There are two major types of rivers in Mizoram according to their direction of flow; rivers which flow in North direction namely, Langkaih, Teirei, Tut, Tlawng, Lau, Meidum, Tuichhuahen, Chemlui, Serlui, Turial, Tuirini, Tuivawl, Tuivai and Tuisa; and rivers flowing in Southern direction namely, Khawthlangtuipui, Tuichawng, Mar, De, Kau, Phairuang, Chhimtuipui, Ngengpui, Palak, Mat, Ngengrual, Vanva, Tuichang, Tuipui and Tiau.

Figure 17: Major River in Mizoram



Source: Action plan for Conservation of nine rivers in Mizoram, 2019

The table represent major river basin and their catchment area in km^2. The barak river alone cover around 8935 km^2 in Mizoram followed by Kolodyne Basin (8144 km^2) and Karnaphuli Basin (3998 km^2).

Table 4 : Important Rivers of Mizoram

S. No.	Name of River	Basin	Catchment Area (km2)
1	Tlawng	Barak River	919.8
2	Tuisa	Barak River	394
3	Tuiritai	Barak River	945.2

4	RB Tuivai	Barak River	560.3
5	Langkaih	Barak River	347.4
6	Tlawng II	Barak River	832.9
7	Tlawng I	Barak River	417.8
8	M-Tuirial	Barak River	524.8
9	Tuivawl	Barak River	963
10	LB Tuivai	Barak River	348.2
11	Tut I	Barak River	887.4
12	RB Barak	Barak River	130.5
13	Serlui	Barak River	580.3
14	L-Tuirial	Barak River	397.8
15	Tlawng, Teirei I	Barak River	685.3
Barak basin total			**8,934.70**
1	Ngengpui Lui	Kolodyne River	673.3
2	Tuichang l	Kolodyne River	1,024.90
3	Kawlawh	Kolodyne River	615.7
4	Mat	Kolodyne River	928.2
5	Tiau	Kolodyne River	775.7
6	Tuichang ll	Kolodyne River	778
7	Tuisih Lui	Kolodyne River	524.5
8	Chhimtuipui	Kolodyne River	829.2
9	Chhimtuipui, Tiau	Kolodyne River	598.4
10	Zuva	Kolodyne River	210.3
11	Sekul Lui	Kolodyne River	252
12	Tuipui	Kolodyne River	934
Kolodyne Basin total			**8,144.20**
1	Sazuk Lui	Karnaphuli River	144.5
2	Khawthlang Tuipui	Karnaphuli River	693.4
3	Kawrpui	Karnaphuli River	356.5
4	Mar Lui	Karnaphuli River	648.4
5	Tuichawng I	Karnaphuli River	573.1
6	Tuichawng	Karnaphuli River	605.3
7	De-Phairuang, Kau	Karnaphuli River	977.3
Karnaphuli Basin total			3,998.50
Total Catchment area			**21,077.40**

Source: Mizoram Remote Sensing Application Centre (MIRSAC)

3.4 Soil and water conservation practices in Mizoram under FOCUS project

3.5 Sediment Yield

Soil is one of the most important non-renewable natural resources. The process of soil erosion involves three distinct stages: the separation of soil particles, the transfer of particles, and the sedimentation of transported particles. Soil erosion is a global concern due to its economic and environmental impacts and has received increasingly more attention from researchers in recent years. Protecting soil erosion is crucial due to its effects on soil fertility, water quality, and flooding prediction. Due to soil erosion, millions of tons of sediments enter reservoirs and cause a decrease in their storage capacity, damage to dams, reduction of the life of dams, changes in water quality, and tremendous economic losses. In order to implement programs to control soil erosion and reduce sedimentation, it is necessary to estimate the total volume of sedimentation and the intensity of erosion from a watershed and identify the factors influencing the erosion of the watershed. Identification of these factors will help choose appropriate approaches to control erosion and conserve natural resource.

The MPSIAC method is used to calculated to sediment yield of Mizoram. The method depends upon 9 effective factors with respect to soil erosion, including geology, soils, climate, runoff, topography, land cover, land use, upland erosion, and channel erosion, has been evaluated. Brief explanations of these factors are presented below.

Surface Geology Factor (f_1): The surface geology factor is related to the geologic erosion index (Y1) determined by rock types and their characteristics. Loose rocks are usually easily exposed to erosion and play a key role in sediment yield. Depending on the resistance degree of rocks against erosion, the values of this factor may vary from 0 and 10.

Soil Factor (f_2): This factor is estimated using 16.67 × k, in which k is the soil erodibility factor depending on soil texture and the amount of silt, lime, gravel, and organic matter in soil. The range of changes for this factor is based on soil texture, stability of aggregates, amount of lime, organic matter, ability to spread clay particles, and soil moisture.

Climate Factor (f_3): The amount of runoff from a watershed depends on the amount and intensity of precipitation. The amount and intensity of precipitation influence the amount of erosion. This factor depends on the frequency of precipitation, the intensity of precipitation, and the period of precipitation, snow, ice, and melting. This factor is determined by 0.2 × P_2, in which P_2 is the precipitation amount during a period of 6 h with a return period of 2 years (mm).

Runoff Factor (f_4): To assess the effect of runoff on soil erosion, it is necessary to consider the hydrological characteristics of the watershed, such as the specific flow of floods ($m^3s^{-1}km^{-2}$), the specific flow with different return periods, and the hydrological groups of soils. The runoff factor is estimated by f4 = 0.006R + 10QP, in which R is the total average runoff depth (mm) that is interpolated from measurements at the meteorological stations, and QP is the peak special discharge ($m^3s^{-1}km^{-2}$) determined from the peak discharge at the hydrological units.

Topography (f_5): The topography factor is usually determined in accordance with the average slope of a watershed. Erosion usually increases with the slope of a watershed because of the increase in the speed of the runoff generated from a watershed. This factor can be calculated by 0.33 × S, in which S is the average slope of a watershed in percentage. The map of the average slope can be generated from the digital elevation model. The topography factor is very important in determining soil erosion from a watershed in the MPSIAC method by considering the score of this factor ranging from 0 to 20.

Ground Cover (f_6): Vegetation, litter, and rocks are types of ground cover. The presence of any of these three covers can have positive effects on preventing the watershed from soil erosion and sediment yield. The ground cover factor can be determined by 0.2 × P_b, in which Pb is the percentage of the bare cover accounted for in a watershed. The value of this factor ranges from -10 to 10.

Land Use (f_7): To determine this factor, two criteria are usually considered: the first is agricultural activities, and the second is livestock grazing status. If agricultural activities are not common at the basin level, or the watershed area is covered with dense vegetation and is less likely to be domesticated, the role of this factor in soil erosion and the sediment yield from this watershed are negative. This factor can be determined by 20 - 0.2 P_C, in which P_C is the coverage of the plant canopy in percentage. The value of the land use factor ranges from -10 to 10.

Upland Erosion (f_8): Surface erosion in a watershed is assessed using this factor. This factor is considerably important for determining the sediment yield from a watershed, with a score ranging from 0 to 25. To assess the surface factor of soil (S.S.F.), seven aspects are considered, including soil mass movement, petiole cover, rock surface cover, pedestalling rock fragments, surface grooves, waterway form, and development of ditch erosion. This factor is estimated by 0.25 × S.S.F., in which S.S.F. is the sum of scores in the BLM method.

Channel Erosion (f_9): Regarding the erosion from channels in a watershed, both erosion from channel banks and sediment transport by the flow are examined. Channel erosion is the result of the destruction of channel banks, which occurs mostly during floods and watery seasons. Some factors that have major effects on the deformation of the channel bed and sediment transport are the average slope of riverbeds, type of rocks along rivers and potential energy of floods. This factor ranges from 0 to 25 and can be calculated by 1.67 × SSF.g, in which SSF.g is the gully erosion in the BLM method.

Sediment Flux (Yield): Based on the degree of impact of each factor, scores are assigned to each factor Finally, the total score is calculated, and the annual rate of sediment yield (Q_S) is estimated by the following equation.

$$Qs = 38.77e^{0.0353R}$$

where R is the total sum of factors, and Q_S is the annual rate of sediment yield from each sub-basin in m^3/km^2. In this method, the amount of soil erosion of each unit is called sediment load, which is the sum of suspended load and bed load. The sediment yield has been classified according to the class which represent the sediment production at different range.

Sediment yield classes

Sediment Production $m^3/km^2/year$	Sediment yield intensity	Sediment yield class
>1429	Very high	V
476–1429	high	IV
238–476	Moderate	III
95–238	Low	II
<95	Very low	I

Effective factors on the erosion and calculation method.

Description	Effective factors	Equation	Calculated Value
Surface Geology Factor (f_1)	Surface Geology		5.00
Soil Factor (f_2)	Soil	16.67 × k	8.00
Climate Factor (f_3)	Climate	$0.2 \times P_2$	22.64
Runoff Factor (f_4)	Runoff	$f4 = 0.006R + 10Q_P$	5.84
Topography (f_5)	Topography	0.33 × S	11.55
Ground Cover (f_6)	Land Cover	$0.2 \times P_b$	4.45
Land Use (f_7)	Land Use	$20-0.2\ P_C$	4.20
Upland Erosion (f_8)	Surface Erosion	0.25 × S.S.F	10.50
Channel Erosion (f_9)	Gully Erosion	1.67 × SSF.g	5.01
Total Value R (f1+f9)			**77.19**

Source: Consultant's analysis

Note: k= 0.48, P_2 = 113.2 mm (Max rainfall 24 Hrs), Average area of watershed (km^2) = 619.92, Rainfall (R)–113.2 mm (in 24 hrs), $Q_P = 0.278$ C x I x A, where Qp: peak discharge (m^3/s), A: area of river basin (km^2), I: maximum rain intensity for the same time concentration (mm/h), C: surface flow coefficient, and 0.278: coefficient. Slope (s) – 35%, bare cover (Pb) = 22.25, Coverage of the plant canopy (P_c) = 79%, SSF = 42, SSFg = 3,

Sediment Yield of Mizoram (Qs) = 38.77e^0.0353R = 591.38(m^2/km^2/Year)

According to the MPSIAC model, the sediment yield has been calculated and it has shown that the value comes under sediment yield class IV, which is considered to be high.

3.6 Spring Discharge in Mizoram

A spring is a natural source of groundwater that rises to the land surface. This water can flow out due to gravity from a water table aquifer or from pressure within an artesian aquifer. Springs can be classified into two types: gravity springs and artesian springs. Gravity springs occur when the land surface intersects the water table through cracks or fractures, causing water to flow horizontally out of the ground. Conversely, artesian springs form when water becomes trapped between layers of impermeable rock and is pushed to the surface under pressure. A gravity spring can occur at a distinct point as a concentrated spring. It is unhidden and often found along hillsides where groundwater is forced through openings in fracture bedrock. The other type, seepage spring occurs when shallow groundwater seeps from the ground over a large area and has no defined discharge point.

Springs are one of the vital sources of water in the Mizoram district of North-Eastern hilly state of India. However, there is a lack of literature on spring water serviceability, recharge potentiality and spring watershed management. In this section, the spring assessment and discharge rate has been calculated based on the secondary and primary research to understand the current scenario of the project district. In order to exploit the water from the springs and allocate it to the different needs, information is needed about the quantity of water supply, the changes in discharge during different months of the year and during periods of drought, and also the quality of the water. Therefore, it is necessary to continuously monitor the quality and quantity of spring water. Planning the use of water from such springs is very difficult because there is no reliable basic information to estimate the amount of spring water and conduct accurate planning. Therefore, providing reliable methods for estimating (predicting) the discharge from such springs where long-term hydrometric data are unavailable is crucial.

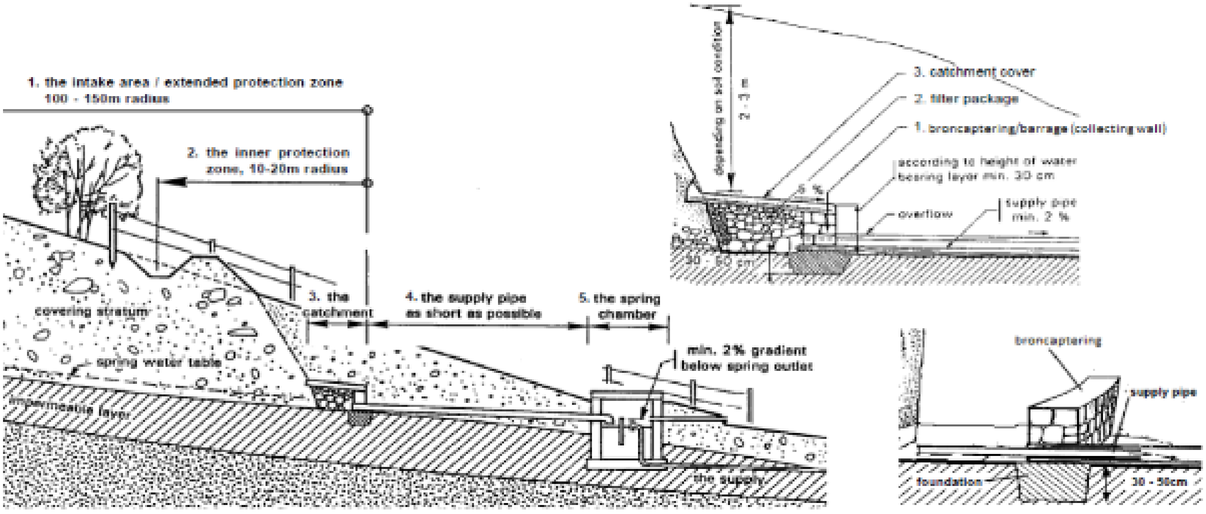
Methods of Spring Development

According to the Directorate General of Human Settlements, Ministry of Public Works, there are three categorizations of spring development. Firstly, based on the spring type, springs can be divided into four types, namely Type 1A (concentrated artesian spring type), Type 1B (seepage artesian spring type), Type 1C (vertical artesian spring type), and Type 1D (gravity contact spring type). The second category is due to the size of spring box, which is one of the main components of spring development, namely Type IIA (volume 4 m^3), Type IIB (volume 8 m^3), and Type IIC (volume 10 m^3). The third category is based on how the spring water will be conveyed, whether by gravity flow or by a pumped system.

Catchment Area of Spring

The catchment area has divided into five components as shown in Figure below. The intake area includes the area from which the spring is supplied (by infiltration and percolation of rainwater) to the spot where the water comes to the surface. the other components are the catchment, the supply pipe, and the spring chamber or spring box. The typical spring catchment consist of three elements, namely a broncaptering (collecting wall), a permeable construction behind the broncaptering (either in the form of a filter package or as a perforated pipe), and a catchment cover.

Figure 18: Key components catchment area of springs



Source: Secondary research

Potential Resource Due to Spring Discharge:

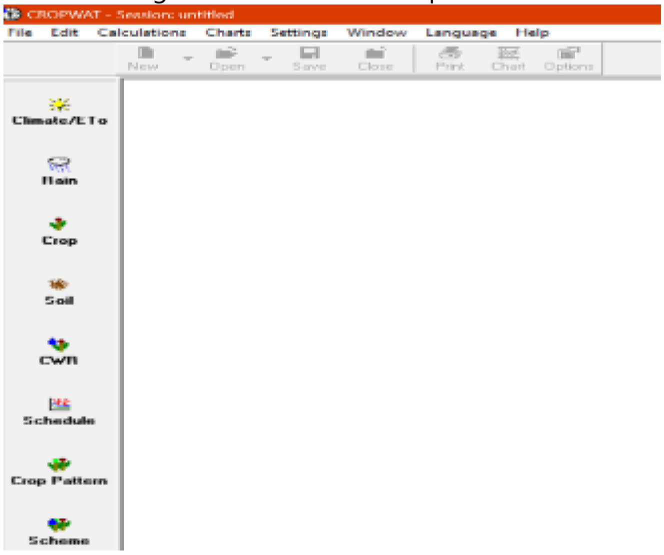
During field investigation it was found that only springs are easily accessible source for water. A large number of springs are noticed which are found in all places and altitude.

Spring discharge constitutes an additional source of ground water in hilly areas which emerges at the places where ground water level cuts the surface topography. **The spring discharge is equal to the ground water recharge minus the outflow through evaporation and evapotranspiration and vertical and lateral sub-surface flow.**

According to the CGWB Ground water exploration indicates that yield potential of deep tubewells within the depth range of 200 m tapping Tertiary sandstone ranges from 120 to 330 liters per minute for drawdown of 13 to 20 m. The transmissivity ranges from 11 to 46 m^2/day. It was considered that during monsoon season discharge of a spring ranges from **2.0 - 168.0 litre per second** and during non-monsoon season the discharge ranges from **1.0 - 84.0 litre per second**.

3.7 Water requirement for Rice Corp

CROPWAT Model CROPWAT 8.0 is a free software for calculating the water demand of plants based on soil, climate and plant data. In addition, the program enables the development of irrigation plans for different management conditions and the calculation of the supply system of the different cultivation patterns. CROPWAT 8.0 can also be used to assess farmers' irrigation practices and estimate crop yield in both rain-based cultivation and irrigated conditions.



To execute a simulation of CROPWAT model, it is necessary to have sets of data: climate data, rain data, crop data, soil data and irrigation criteria. Climatic condition determines evapotranspiration computed by Penman Monteith formula, which is implemented in CROPWAT.

The meteorological parameters used to calculate ETo were latitude, longitude and altitude of the station, maximum and minimum temperature (°C), maximum and minimum relative humidity (%), wind speed (km / day) and hours of sunshine. The properties of the soil taken into account for the estimation of the water requirement of the cultivated plants are the content of available water (mm / m) and the depth of the soil (cm). The Penman-Monteith equation was adopted to calculate reference crop evapotranspiration due to it accurate output by using different meteorological variables in the study area.

In order to compute the crop water requirement (CWR), crop coefficient (Kc) values for the, rice, wheat and maize crop were obtained and multiplied with the reference evapotranspiration.

Calculation of Crop Evapotranspiration

The Penman-Monteith Method was used to determine the Reference Evapotranspiration (ET0) using the equation (1).

$ETo = 0.408 \triangle (Rn-G) + \gamma (900/T + 273) u2 (es-ea) \triangle + \gamma (1+0.34 u2)$ ——-(1)

Where, ETo represents the reference crop evapotranspiration (mm/ day);
Rn represents net radiation on the crop surface in (MJ /m2 - day) Represents soil heat flux density (MJ/ m2-day ;
T, the average air temperature per day at a height of 2 m (0C);
u2, the speed of wind at a height of 2 m in m/s;
es, the vapour pressure at saturation (kPa);
ea. the actual vapour pressure;
es – ea., the saturation vapour pressure deficit (kPa);
Δ, slope vapour pressure curve
(kPa0C) and γ, the psychometric constant (kPa (0C))

The Penman-Monteith equation was adopted to calculate reference crop evapotranspiration due to it accurate output by using different meteorological variables in the study area.

The reference evapotranspiration (ETO) is multiplied by the crop coefficient (Kc) to obtain crop Evapotranspiration (Etc.), as shown in Equation (2).

$ETc = Kc \times ETO$ (2)

Country: India Station: Aizawl

Altitude: 23 m. Latitude: 24.30 °N Longitude: 91.73 °E

Month	Min Temp °C	Max Temp °C	Humidity %	Wind km/day	Sun hours	Rad MJ/m²/day	ETo mm/day
January	8.5	25.8	86	57	8.1	15.5	2.25
February	11.2	27.9	76	67	7.9	17.3	2.81
March	16.6	32.1	76	119	8.0	19.7	3.99
April	21.0	33.4	79	143	7.0	19.8	4.45
May	23.1	32.6	83	119	5.7	18.5	4.16
June	24.4	31.9	89	129	3.3	15.0	3.42
July	24.9	31.9	89	134	3.1	14.7	3.35
August	24.8	31.8	90	119	3.2	14.3	3.23
September	24.5	32.1	90	88	4.0	14.4	3.20
October	21.6	30.9	89	57	6.4	15.9	3.24
November	15.5	29.0	89	45	7.8	15.5	2.73
December	10.4	26.5	88	45	8.0	14.6	2.21
Average	18.9	30.5	85	94	6.0	16.3	3.25

MONTHLY RAIN DATA
(File: untitled)

Station: Directorate

Eff. rain method: USDA Soil Conservation Service formula:

Peff = Pmon * (125 - 0.2 * Pmon) / 125 for Pmon <= 250 mm

Peff = 125 + 0.1 * Pmon for Pmon > 250 mm

	Rain mm	Eff rain mm
January	8.8	8.7
February	23.5	22.6
March	61.8	55.7
April	137.6	107.3
May	296.2	154.6
June	412.7	166.3
July	393.1	164.3
August	426.0	167.6
September	335.3	158.5
October	194.8	134.1
November	24.1	23.2
December	10.0	9.8
Total	2323.9	1172.7

DRY CROP DATA
(File: untitled)

Crop Name: Rice Planting date: 17/05 Harvest: 13/09

Stage	initial	develop	mid	late	total
Length (days)	25	35	30	30	120
Kc Values	1.10	-->	1.20	1.05	
Rooting depth (m)	0.10	-->	0.60	0.60	
Critical depletion	0.20	-->	0.20	0.20	
Yield response f.	1.00	1.09	1.32	0.50	.5
Cropheight (m)			1.00		

SOIL DATA
(File: C:\ProgramData\CROPWAT\data\soils\RED SANDY LOAM.SOI)

Soil name: RED SANDY LOAM

General soil data:

Total available soil moisture (FC - WP)	140.0	mm/meter
Maximum rain infiltration rate	30	mm/day
Maximum rooting depth	900	centimeters
Initial soil moisture depletion (as % TA	0	%
Initial available soil moisture	140.0	mm/meter

CROP WATER REQUIREMENTS

ETo station: Aizawl Crop: Rice
Rain station: Directorate Planting date: 17/05

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
May	2	Init	1.10	4.57	18.3	21.3	0.0
May	3	Init	1.10	4.30	47.3	53.9	0.0
Jun	1	Init	1.10	4.03	40.3	54.5	0.0
Jun	2	Deve	1.10	3.77	37.7	56.0	0.0
Jun	3	Deve	1.11	3.77	37.7	55.6	0.0
Jul	1	Deve	1.12	3.76	37.6	54.9	0.0
Jul	2	Mid	1.12	3.75	37.5	54.6	0.0
Jul	3	Mid	1.12	3.71	40.8	55.0	0.0
Aug	1	Mid	1.12	3.67	36.7	55.9	0.0
Aug	2	Late	1.11	3.59	35.9	56.4	0.0
Aug	3	Late	1.06	3.41	37.6	55.2	0.0
Sep	1	Late	1.01	3.23	32.3	54.3	0.0
Sep	2	Late	0.97	3.11	9.3	16.1	0.0
					449.1	643.7	0.0

CROP IRRIGATION SCHEDULE

ETo station: Aizawl	Crop: Rice	Planting date: 17/05
Rain station: Directorate	Soil: RED SANDY LOAM	Harvest date: 13/09

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at 100 % depletion
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	Eta %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
17 May	1	Init	50.3	1.00	100	30	4.6	0.0	0.0	6.5	0.76
18 May	2	Init	0.0	1.00	100	28	4.6	0.0	0.0	6.5	0.76
19 May	3	Init	0.0	1.00	100	26	4.6	0.0	0.0	6.5	0.76
20 May	4	Init	0.0	1.00	100	25	4.6	0.0	0.0	6.5	0.76
21 May	5	Init	0.0	1.00	100	22	4.3	0.0	0.0	6.1	0.71
22 May	6	Init	0.0	1.00	100	20	4.3	0.0	0.0	6.1	0.71
24 May	8	Init	0.0	1.00	100	37	8.6	0.0	0.0	12.3	0.71
26 May	10	Init	0.0	1.00	100	34	8.6	0.0	0.0	12.3	0.71
28 May	12	Init	0.0	1.00	100	31	8.6	0.0	0.0	12.3	0.71
30 May	14	Init	0.0	1.00	100	28	8.6	0.0	0.0	12.3	0.71
1 Jun	16	Init	0.0	1.00	100	26	8.3	0.0	0.0	11.9	0.69
4 Jun	19	Init	0.0	1.00	100	22	8.1	0.0	0.0	11.5	0.44
6 Jun	21	Init	0.0	1.00	100	21	8.1	0.0	0.0	11.5	0.67
9 Jun	24	Init	0.0	1.00	100	29	12.1	0.0	0.0	17.3	0.67
12 Jun	27	Dev	0.0	1.00	100	25	11.6	0.0	0.0	16.5	0.64
15 Jun	30	Dev	0.0	1.00	100	23	11.3	0.0	0.0	16.2	0.62
19 Jun	34	Dev	0.0	1.00	100	21	11.3	0.0	0.0	16.2	0.47
26 Jun	41	Dev	0.0	1.00	100	24	15.1	0.0	0.0	21.5	0.36
30 Jun	45	Dev	0.0	1.00	100	23	15.1	0.0	0.0	21.5	0.62
6 Jul	51	Dev	0.0	1.00	100	20	15.0	0.0	0.0	21.5	0.41
11 Jul	56	Dev	0.0	1.00	100	24	18.8	0.0	0.0	26.9	0.62
21 Jul	66	Mid	0.0	1.00	100	22	18.7	0.0	0.0	26.8	0.31
31 Jul	76	Mid	0.0	1.00	100	22	18.6	0.0	0.0	26.5	0.31
11 Aug	87	Mid	0.0	1.00	100	22	18.3	0.0	0.0	26.1	0.27
21 Aug	97	End	0.0	1.00	100	21	17.8	0.0	0.0	25.4	0.29
31 Aug	107	End	0.0	1.00	100	20	17.1	0.0	0.0	24.4	0.28
12 Sep	119	End	0.0	1.00	100	23	19.2	0.0	0.0	27.4	0.26
13 Sep	End	End	0.0	1.00	0	0					

Totals:

Total gross irrigation	436.5	mm	Total rainfall	1575.	mm
Total net irrigation	305.6	mm	Effective rainfall	140.4	mm
Total irrigation losses	0.0	mm	Total rain loss	1435.	mm
Actual water use by crop	445.9	mm	Moist deficit at harvest	0.0	mm
Potential water use by crop	445.9	mm	Actual irrigation requirement	305.6	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	8.9	%
Deficiency irrigation schedule	0.0	%			

Source: Consultants analysis through CROPWAT 8.0

Crop water requirement of Rice

To determine the crop water requirement of rice, the CROPWAT Software was utilized, integrating various crop parameters for accurate estimation. These parameters encompass the crop coefficient (KC), length of the growing season, critical depletion level, and yield response factor (Ky). The tables presented detail the adopted crop parameters specifically tailored for rice cultivation, serving as the basis for calculating the crop water requirement. The analysis unveiled that the total crop water requirement for rice cultivation amounted to 445.9 millimeters throughout the growth period spanning 150 days. This calculation is crucial for effective water management in rice cultivation, ensuring optimal growth and yield. By accurately assessing the water needs of rice crops, farmers can implement appropriate irrigation strategies, avoiding both water stress and excessive water usage.

Moreover, understanding the crop water requirement aids in resource allocation and planning, particularly in regions where water availability is limited or prone to variability. By incorporating such data-driven approaches, agricultural practices can be optimized, enhancing productivity while conserving water resources. This comprehensive assessment underscores the significance of considering crop-specific water requirements in agricultural planning and management strategies, promoting sustainable and efficient farming practices.

Chapter 4

Impact Assessment

A

Commodity Outreach

The FOCUS project has successfully targeted a significant number of commodities within the project district, covering over 3,237 commodities. In addition, more than 300 lead farmers (275 male and 25 female) also covered under FOCUS project.

Table 5 : Commodity Outreach under FOCUS project

Name of Commodity	Champhai	Kolasib	Serchhip	Mamit	Saitual	Khawzawl	Total
Jhum	149	14	65	220	86	138	672
Settled Agri	194	367	145	292	216	135	1349
WRC/TRC	143	116	64	82	65	58	528
Landless	33	34	23	62	77	25	254
CCA	35	45	37	44	40	31	232
Value Chain	32	36	16	84	29	5	202
Total	586	612	350	784	513	392	3237

Source: Annual Report 2023

B

Direct Beneficiaries – Through the commodity outreach total 54,509 no of member benefited and out of total 18,258 are women.

Table 6 : Beneficiaries outreach

District	Name of FIG commodity													
	Jhum		Orchard		WRC		Landless		CCA		Value Chain		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Champhai	1761	967	2466	1098	1944	640	398	180	135	39	443	162	7147	3086
Kolasib	219	49	4528	1907	1166	565	345	237	168	50	225	204	6651	3012
Serchhip	750	401	1701	800	701	392	171	198	421	161	161	104	3905	2056
Mamit	2304	1658	3102	2304	831	577	536	442	181	60	646	876	7600	5917
Saitual	1027	504	2542	1299	879	287	931	453	155	41	392	131	5926	2715
Khawzawl	1809	582	1807	568	828	155	384	106	117	38	77	23	5022	1472
Total	7870	4161	16146	7976	6349	2616	2765	1616	1177	389	1944	1500	36251	18258

Source: Consultant's Analysis

C

There are more than 1 lakhs beneficiaries under the water and soil conservation activities implemented in the project districts

Table 7 : Beneficiaries under soil and water conservation activities

Type of Activities	Unit	Total	Average HH benefited per Site	No of HH benefited	No of beneficiaries	No of Women Benefited
Low-Cost Bunds	HH	6713	2.18	14623	43868	13160

Type of Activities	Unit	Total	Average HH benefited per Site	No of HH benefited	No of beneficiaries	No of Women Benefited
Protection of water source	Sites	956	13.21	12631	37892	11368
Water Storage & Delivery System	Per System	815	2.69	2190	6570	1971
Bench Terrace	Ha	945	2.51	2372	7117	2135
Water Harvesting Structure	Nos	221	9.43	2084	6251	1875
				33899	**101698**	**30509**

Source: Consultant's Analysis

4.1 Impact on Ground water Recharge

Groundwater recharge involves both natural processes within the hydrologic cycle and human-induced methods. Natural recharge occurs through precipitation infiltrating and percolating through the soil, while human-induced recharge can be achieved directly through spreading basins, injection wells, or indirectly through activities like irrigation and waste disposal. Artificial recharge using excess surface water or reclaimed wastewater is becoming increasingly common, making it a significant part of the hydrologic cycle. Under FOCUS- Mizoram project various water protection structure has been constructed to recharge the ground level.

Natural recharge to the water table can be either diffuse or localized. Diffuse recharge occurs when water from widespread precipitation infiltrates and moves down through the unsaturated zone to the water table. Localized recharge happens when water from surface bodies like rivers or lakes infiltrates the groundwater system. This type of recharge is more unevenly distributed compared to diffuse recharge. Most groundwater systems benefit from a combination of both diffuse and localized recharge, ensuring a steady replenishment of the water table.

According to the CGWB report, the Dynamic Ground Water Resources of Mizoram are located in safe zone. Similarly for the project district are also comes under safe zone. The method for calculating the GWR are described below:

Box 1: Natural Ground water recharge of Mizoram

Total annual ground water recharge

The total annual ground water recharge of the area is the sum-total of monsoon and non-monsoon recharge. An allowance is kept for natural discharge in the non-monsoon season by deducting 5% of total annual ground water recharge, if WLF method is employed to compute rainfall recharge during monsoon season and 10% of total annual ground water recharge if RIF method is employed. The balance ground water available accounts for existing ground water withdrawal for various uses and potential for future development. This quantity is termed as Annual Extractable Ground Water Resources.

Annual Extractable Ground Water Resources (AEGR) = Annual Ground Water Recharge – Natural discharge during non-monsoon season

Recharge from ponds

1.4 mm/day for the period in which the pond has water, based on the average area of water spread. If data on the average area of water spread is not available, 60% of the maximum water spread area may be used instead of average area of the water spread.

So, Rt wet = pond area × 1.4 (mm/day) × (no. of days)

Recharge from percolation tanks

50% of gross storage, considering the number of fillings, with half of this recharge occurring in the monsoon season, and the balance in the non-monsoon season.

Recharge due to check dams and nala bunds

Box 1: Natural Ground water recharge of Mizoram

50% of gross storage (assuming annual desilting maintenance exists) with half of this recharge occurring in the monsoon season, and the balance in the non-monsoon season.

Norms for estimation of recharge

GEC 2015 methodology has recommended norms for various parameters being used in ground water recharge estimation. These norms vary depending upon water bearing formations and agroclimatic conditions. While norms for specific yield and recharge from rainfall values are to be adopted within the guidelines of GEC 2015, in case of other parameters like seepage from canals, return flow from irrigation, recharge from tanks & ponds, water conservation structures, results of specific case studies may replace the adhoc norms.

Ground Water Extraction

The gross yearly ground water extraction is to be calculated for Irrigation, Domestic and Industrial uses. The gross ground water extraction would include the ground water extraction from all existing ground water structures during monsoon as well as during non-monsoon period. While the number of ground water structures should preferably be based on latest well census, the average unit draft from different types of structures should be based on specific studies or adhoc norms given in GEC 2015 report.

Stage of ground water Extraction & Categorization of units

The stage of Ground water Development is defined by,

$$\text{Stage of Ground water Extraction (\%)} = \frac{\text{Existing Gross Ground water extraction for all uses X 100}}{\text{AEGR}}$$

Categorization of Assessment Units Based on Quantity: The categorization based on status of ground water quantity is defined by Stage of Ground Water Extraction as given below:

Stage of Ground Water Extraction	Category
≤70%	Safe
>70%and ≤90%	Semi-Critical
>90%and ≤100%	Critical
> 100%	Over Exploited

Assessment sub-unit wise method adopted for computing rainfall recharge during monsoon season (WLF/RIF).

Rainfall Infiltration Factor (RIF) method adopted for computing rainfall recharge during monsoon season in the absence of availability of water level data.

Monsoon season

Recharge from rainfall is estimated by using the following relationship -

Rrf = RFIF * A* (R – a)/1000

Where,

Rrf = Rainfall recharge in ha-m

A = Area in hectare

RFIF = Rainfall Infiltration Factor

R = Rainfall in mm

a = Minimum threshold value above which rainfall induces ground water recharge in mm

The threshold limit of minimum and maximum rainfall event which can induce recharge to the aquifer is to be considered while estimating ground water recharge using rainfall infiltration factor method. The minimum threshold limit is in accordance with the relation shown in above equation and the maximum threshold limit is based on the premise that after a certain limit, the rate of storm rain is too high to contribute to infiltration and they will only contribute to surface runoff. It is suggested that 10% of Normal

Box 1: Natural Ground water recharge of Mizoram

annual rainfall may be taken as minimum rainfall threshold and 3000 mm as maximum rainfall limit. The resources assessment during monsoon season is estimated as the sum total of the change in storage and gross draft. The change in storage is computed by multiplying water level fluctuation between pre and post monsoon periods with the area of assessment and specific yield.

Monsoon recharge can be expressed as –

$$R_{RF} = h \times Sy \times A - R_{OS} \pm VF \pm LF + GE + T + E + B$$

Where,

h = rise in water level in the monsoon season,
A = area for computation of recharge,
Sy = specific yield, D_G = gross ground water draft,
R_{OS}= Other sources of ground water recharge during monsoon season include Rc, Rsw, Rt, Rgw, Rwc which are recharge from seepage from canals, surface water irrigation, tanks and ponds, ground water irrigation, water conservation structures respectively.
LF = Recharge through Lateral flow/ Through flow across assessment unit boundary in the monsoon season for the i^{th} particular year,
VF – Vertical inter aquifer flow in the monsoon season for the i^{th} particular year,
T- Transpiration in the monsoon season for the i^{th} particular year,
E- Evaporation in the monsoon season for the i^{th} particular year,
GE = Ground water extraction in monsoon season for the i^{th} particular year,
B = Base flow the monsoon season for the i^{th} particular year

The monsoon ground water recharge has two components – rainfall recharge and recharge from other sources. Mathematically it can be represented as –

$$R(Normal) = R_{RF}\ (normal) + R_{OS}$$

Where,

Rrf is the normal monsoon rainfall recharge. R_{OS} is the other sources of ground water recharge during monsoon season include Rc, Rsw, Rt, Rgw, Rwc which are recharge from seepage from canals, surface water irrigation, tanks and ponds, ground water irrigation, water conservation structures respectively.

Non-Monsoon season

During non-Monsoon season, rainfall recharge is computed by using Rainfall Infiltration Factor (RIF) method. Recharge from other sources is then added to get total non-Monsoon recharge. In case of areas receiving less than 10% of the annual rainfall during non-monsoon season, the rainfall recharge is ignored.

Table 8 : Assessment of Dynamic Ground Water Resources of Mizoram (As on March 2022) in Ham

S. No	District	Assessment unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area (Ha)	Recharge from Rainfall- Monsoon Season	Recharge from Rainfall- Non-Monsoon Season	Total Annual Ground Water Recharge (Ham)	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Domestic use (Ham)	Total Extraction (Ham)	Stage of ground Wate Extraction (%)	Categorization
1	Aizawl	Thingsulthliah	73100	4161	247.96	65.21	313.17	31.32	281.85	17.51	17.51	6.21	Safe
2	Kolasib	Bilkhawthlir	51106	18978	1093.21	242.24	1335.45	133.55	1201.90	23.05	23.05	1.92	Safe
3	Lawngtlai	Chawngte	69948	24542	1394.08	136.55	1530.63	153.06	1377.57	31.37	31.37	2.28	Safe
4	Champhai	Khawzawl	113287	9486	479.12	86.40	565.52	56.55	508.97	7.42	7.42	1.46	Safe
5	Aizawl	Darlawn	105043	7623	454.27	119.47	573.74	57.37	516.37	20.2	20.2	3.91	Safe
6	Lunglei	Lunglei	108893	9850	662.75	61.90	724.65	72.47	652.18	63.57	63.57	9.75	Safe
7	Lawngtlai	Sangau	47258	1781	101.17	9.91	111.08	11.11	99.97	8.06	8.06	8.06	Safe
8	Mamit	Reiek	83627	11650	710.32	201.92	912.24	91.22	821.02	29.63	29.63	3.61	Safe
9	Serchhip	Serchhip	97659	12320	598.6	88.56	687.16	68.72	618.44	21.54	21.54	3.48	Safe
10	Serchhip	Elungdar	44441	3846	186.87	27.65	214.52	21.45	193.07	28.67	28.67	14.85	Safe
11	Saina	Tuipang	96752	8394	570.09	66.58	636.67	63.69	572.98	11.78	11.78	2.06	Safe
12	Aizawl	Phullen	55890	3343	199.22	52.39	251.61	25.16	226.45	13.63	13.63	6.02	Safe
13	Lawngtlai	Lawngtlai	88293	11093	630.13	61.72	691.85	69.19	622.66	61.79	61.79	9.92	Safe
14	Aizawl	Aibawk	55064	131	7.81	2.05	9.86	0.99	8.87	6.17	6.17	69.56	Safe
15	Champhai	Champhai	59080	8096	408.91	73.74	482.65	48.27	434.38	30.01	30.01	6.91	Safe
16	Aizawl	Tlangnuam	68503	6476	385.92	101.49	487.41	48.74	438.67	149.44	149.44	34.07	Safe
17	Champhai	Khawbung	66535	5495	277.54	50.05	327.59	32.76	294.83	1.52	1.52	0.52	Safe
18	Kolasib	North Thingdawl	87094	20537	1183.01	262.13	1445.14	144.51	1300.63	9.49	9.49	0.73	Safe
19	Lunglei	West Bunghmun	114970	24717	1663.06	155.32	1818.38	181.84	1636.54	27.6	27.6	1.69	Safe
20	Saiha	Saiha	43148	2266	153.9	18.03	171.93	17.19	154.74	30.3	30.3	19.58	Safe
21	Mamit	West Phaileng	99578	20459	1247.43	354.60	1602.03	160.2	1441.83	36.65	36.65	2.54	Safe
22	Lawngtlal	Bungtlang South	50201	14659	832.69	81.56	914.25	91.43	822.82	4.65	4.65	0.57	Safe
23	Lunglei	Hnahthial	94597	5275	354.92	33.15	388.07	38.81	349.26	61.67	61.67	17.66	Safe
24	Mamit	Zawlnuam	117195	39522	2409.74	685.00	3094.74	309.47	2785.27	37.69	37.69	1.35	Safe
25	Lunglei	Lungsen	137240	34645	2331.05	217.91	2548.96	254.88	2294.08	49.48	49.48	2.16	Safe
26	Champhai	Ngopa	79598	5596	282.64	50.97	333.61	33.34	300.27	7.74	7.74	2.58	Safe
	Total (Ham)		**2108100**	**314941**	**18866.41**	**3306.5**	**22172.91**	**2217.29**	**19955.62**	**790.63**	**790.63**	**3.96**	**SAFE**
	Total BCM		**21.08**	**3.15**	**0.91**	**0.03**	**0.22**	**0.02**	**0.20**	**0.01**	**0.01**		

Source: CGWB, GoI report, 2022

Table 9 : Assessment of Ground Water Resources through water harvesting structure under FOCUS

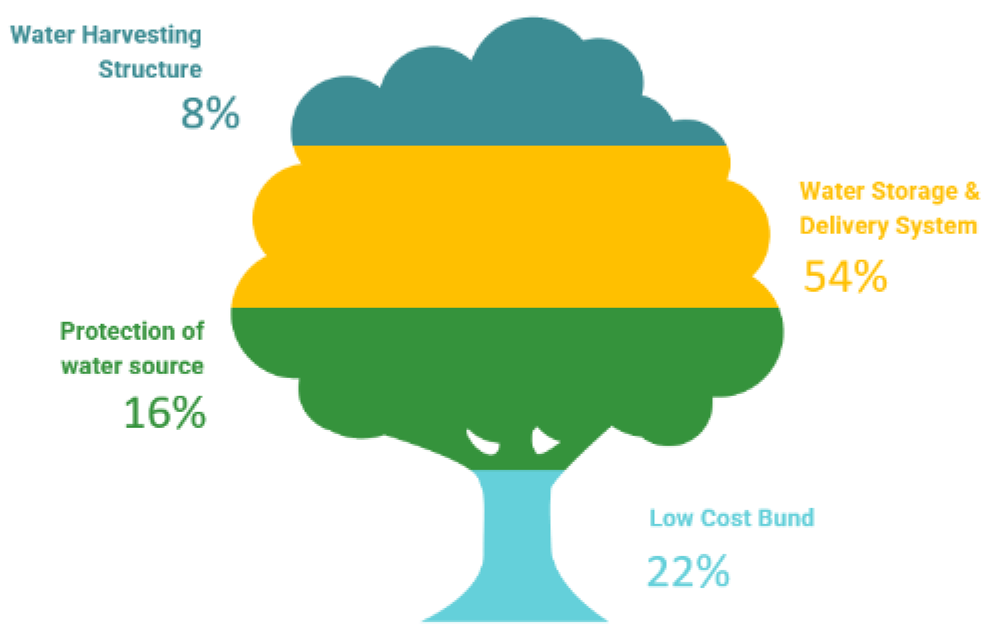
Type of Activities	Unit	Total	Approx Area coverage per structure (Ha)	Water Holing Capacity per site (cubic meter)	Approx Water Storage Capacity (Lakh m^3)	No of Fillings	Estimated Gross Water Harvesting/ Storage (MCM)	Approx Ground Water Recharge (MCM)	Approx Area coverage due to structure (Ha)
Low-Cost Bunds	HH	6713	0.31	428.49	2.876	2.5	7.19	3.60	2054.6
Protection of water source	Sites	956	3.86	2160.96	1.771	2.5	4.43	2.21	3689.1
Water Storage & Delivery System	Per System	815	1.48	8861.11	7.222	2.5	18.05	9.03	1203.6
Bench Terrace	Ha	945	1.44	1150.94	0.816	2.5	2.04	1.02	1359.5
Water Harvesting Structure	Nos	221	1.45	20.11	0.004		0.004		321.2
							31.72	**15.86**	**8628.1**

Source: Consultant's analysis

The groundwater recharge value has been calculated to be approximately 15.86 MCM (0.0158 BCM). When compared to the overall recharge value presented in the previous table, this constitutes about 7.15% of the total groundwater recharge. This significant contribution highlights the effectiveness of the FOCUS Mizoram project's efforts in enhancing groundwater replenishment.

The FOCUS Mizoram project, with its multifaceted approach to soil and water conservation, has generated significant outcomes that resonate both quantitatively and qualitatively within its target regions. Through a meticulous implementation of various interventions, the project has not only augmented groundwater recharge but has also precipitated a cascade of ancillary benefits, amplifying its impact on the local ecosystem and communities.

Figure 19: Ground Water Recharge



Source: Consultant's analysis

Quantitatively, the project's interventions have yielded remarkable results in terms of groundwater recharge. For instance, low-cost bunds, implemented in 6713 households, cover an approximate area of 2054.6 hectares. These structures boast a water holding capacity of 428.49 cubic meters each, contributing to an estimated recharge of 3.60 million cubic meters (MCM). Similarly, the protection of water sources, spanning 956 sites across 3689.1 hectares, with a water holding capacity of 2160.96 cubic meters per site, contributes an estimated 2.21 MCM to groundwater recharge. Additionally, water storage and delivery systems, spread across 815 systems covering approximately 1203.6 hectares, store a staggering 7.222 lakh cubic meters, resulting in an estimated recharge of 9.03 MCM. Bench terraces, covering 945 hectares and boasting a water holding capacity of 1150.94 cubic meters per structure, contribute approximately 1.02 MCM to groundwater recharge. Collectively, these interventions culminate in an estimated total groundwater recharge of approximately 15.86 MCM, representing about 7.15% of the total groundwater recharge in the region.

Qualitatively, the outcomes of the FOCUS Mizoram project extend beyond numerical figures, encapsulating a spectrum of socio-economic and environmental benefits. By bolstering groundwater recharge, the project has not only enhanced agricultural productivity but has also fortified food security and livelihoods within the communities. Moreover, the project's emphasis on community engagement and participatory decision-making has fostered a sense of ownership and stewardship among local stakeholders, ensuring the sustainability and longevity of project interventions. Furthermore, by promoting sustainable water management practices, the project has nurtured resilience within communities, enabling them to withstand the vagaries of climate change and environmental degradation.

In summation, the FOCUS Mizoram project exemplifies the transformative potential of targeted interventions in soil and water conservation. By marrying quantitative achievements with qualitative impacts, the project has ushered in a new paradigm of integrated environmental management, poised to shape the trajectory of sustainable development within its target regions for years to come.

4.2 Impact on Soil and Water conservation

The FOCUS Mizoram project has made significant strides in environmental sustainability through various soil and water conservation practices. These include terracing, which controls soil erosion on hilly terrains, and agroforestry, which enhances soil fertility and water retention. Water harvesting structures like check dams and ponds capture rainwater runoff, refilling groundwater and supporting irrigation during dry periods. Contour farming reduces soil erosion by following natural land contours, while cover cropping protects soil, improves structure, and enhances nutrient cycling. Additionally, watershed management involves conserving and restoring entire watersheds to ensure sustainable water resources. Soil conservation measures such as mulching, crop rotation, and conservation tillage preserve soil structure, reduce erosion, and improve fertility. Together, these practices foster environmental sustainability, enhance agricultural productivity, and build resilience against climate change impacts. These practices include:

4.2.1 Low-Cost Bunds

A low-cost bund has been constructed primarily for shifting cultivation (jhum). Bunding is a crucial agricultural practice to prevent soil and water erosion due to runoff. These bunds are built using materials such as logwood, bamboo poles, tree twigs, banana pseudo stems, or earthen embankments, and are positioned across the slope of the land. The primary functions of these bunds include serving as fences and protecting the soil and water, which helps maintain soil fertility and enhances water infiltration into the soil. The distance between bunds is determined by the land's slope, and crops are cultivated in the areas between these bunds.

Low-cost bunds are embankments constructed along the contours of farmland to slow down water runoff. The FOCUS-Mizoram project has implemented conservation practices over an area exceeding 6,700 hectares. These structures are strategically placed to follow the natural topography, creating barriers that break the speed of flowing water, which in turn helps in multiple ways. The implementation of bunds is a simple yet effective method that significantly enhances the resilience and productivity of agricultural land. It has estimated that creation of bund recharge approx. 3.60 MCM ground water recharge annually.

Type of Activities	Unit	Total	Approx Area coverage per structure (Ha)	Water Holing Capacity per site (cubic meter)	Approx Water Storage Capacity (Lakh m^3)	No of Fillings	Estimated Gross Water Harvesting/ Storage (MCM)	Approx Ground Water Recharge (MCM)	Approx Area coverage due to structure (Ha)
Low-Cost Bunds	HH	6713	0.31	428.49	2.876	2.5	7.19	3.60	2054.6

Source: Consultant's Analysis

In addition, creation of bund directly impacts on the environmental, which have effects in terms of soil erosion, improved water retention, enhanced soil fertility and Runoff preventions.

Soil Erosion Reduction

Low-cost bunds play a crucial role in breaking the flow of water, preventing topsoil from being washed away, and preserving soil fertility. This reduction in soil erosion maintains soil quality by retaining essential nutrients and organic matter vital for crop growth. Stabilizing topsoil also prevents the formation of gullies and rills, which can damage farmland and reduce its usability. Under the FOCUS-Mizoram project, these bunds have been implemented over more than 6,700 hectares, significantly enhancing soil conservation and agricultural productivity. By employing these low-cost bunds, the project ensures the long-term sustainability of farmland, contributing to both environmental and economic benefits for the region.

Improved Water Retention

The low-cost bund slowed water movement allows more water to infiltrate the soil, increasing groundwater recharge and maintaining soil moisture levels. This process ensures that water is available for a longer period after rainfall, benefiting crops during dry spells and reducing the need for supplemental irrigation. Enhanced water retention also supports the microbial life in the soil, which is essential for nutrient cycling and soil health.

Enhanced Soil Fertility

The low-cost bund creates large impact to enhanced soil fertility. With reduced erosion, nutrients remain in the soil, which promotes healthier crops and boosts agricultural productivity. As the bunds prevent the washing away of fertile topsoil, they help in maintaining a rich layer of organic material and minerals. This sustained fertility results in better crop yields and can reduce the dependency on chemical fertilizers, promoting a more sustainable farming approach.

Runoff Prevention

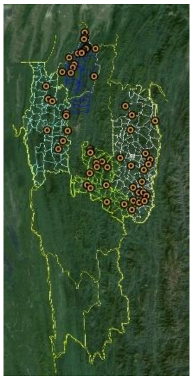
Low-cost Bunds also helped in ensuring that rainwater remains on the field, providing crops with the necessary moisture for growth. By capturing and slowing down runoff, these structures maximize the use of rainfall, allowing it to percolate into the ground rather than being lost. This method not only conserves water but also minimizes the risk of downstream flooding and soil degradation, creating a more stable and productive agricultural environment.

4.2.2 Nursery Establishment

Due to the diverse demography of Mizoram, it is crucial for farmers to have access to the nearest nursery. Transporting seedlings over long distances can lead to their death or poor growth due to lack of moisture and transplant shock. This proximity ensures that the plants are in the best possible condition when they reach the fields, thereby enhancing their chances of survival and growth. Local nurseries are essential for providing the necessary seedlings and reducing the logistical challenges that can compromise agricultural productivity. In situations where government programs or commercial nurseries are unable to supply the desired quantity or species of seedlings, establishing a large regional nursery becomes advantageous. This is especially important for species that require special care before they can be transplanted into the field. A centralized nursery can ensure that these species receive the specific conditions they need for optimal growth. This approach not only addresses the immediate needs of farmers but also supports the long-term sustainability of agriculture in the region by ensuring a steady supply of healthy seedlings.

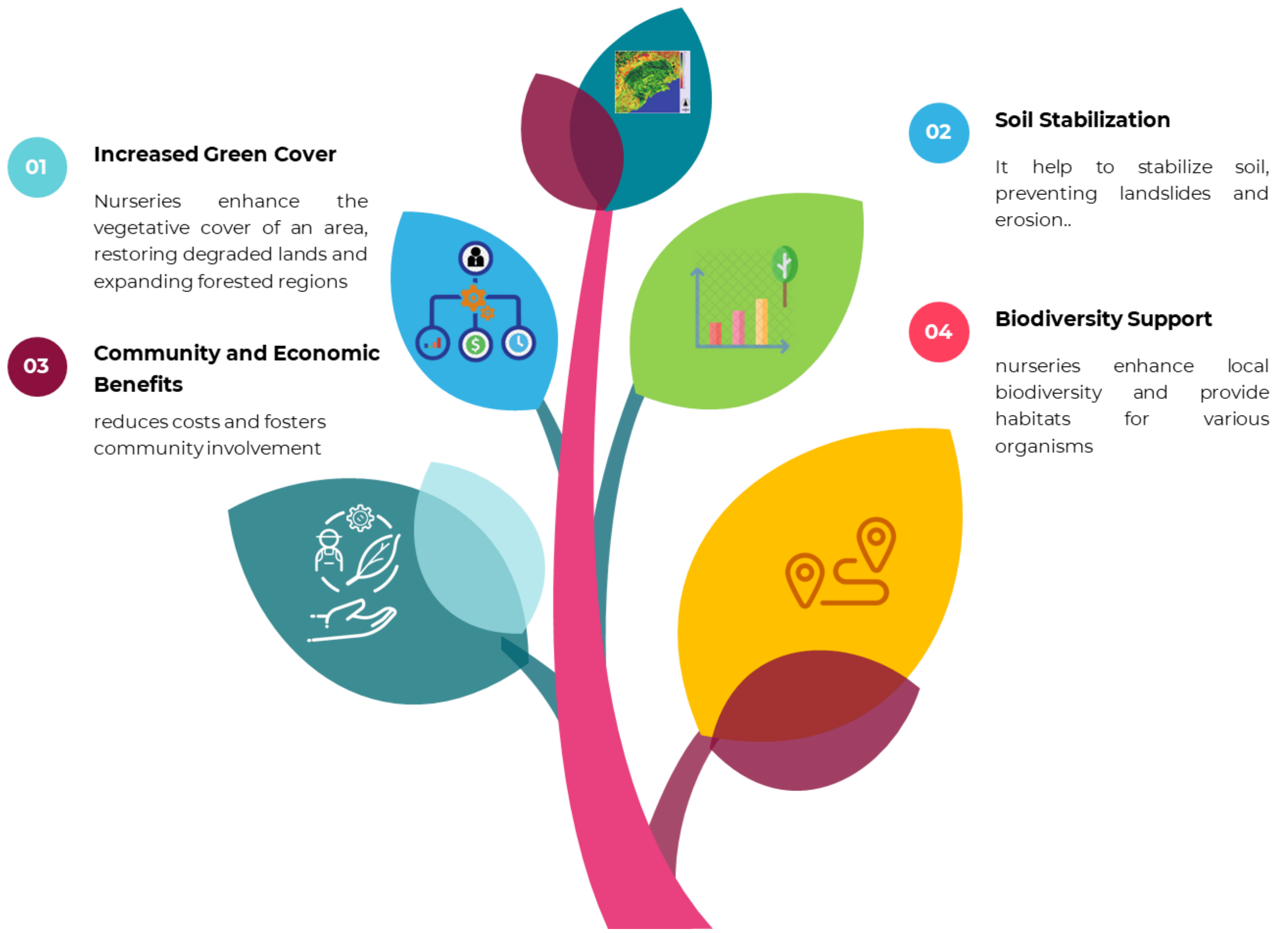
The FOCUS-Mizoram project has responded to these needs by developing nurseries at the local level. These nurseries are designed to support farmers in growing both agricultural and horticultural produce. They can be self-sustaining or maintained with government funds, ensuring their longevity and reliability. The FOCUS-Mizoram project places a strong emphasis on utilizing local materials, labor, and resources, as well as appropriate technologies. This not only reduces costs but also fosters community involvement and economic benefits, as local people are engaged in the nursery operations.

The amount of land allocated for these nurseries depends on the size of the project, its goals, and the availability of land. By tailoring the size of the nursery to the specific needs of the community, the project ensures that it can meet the local demand for seedlings. This strategic approach helped under FOCUS to maintaining the health of the seedlings and supports the broader agricultural and horticultural activities in the region.



Establishing nurseries involves cultivating young plants that are later transplanted to larger areas for reforestation and afforestation. These nurseries play a crucial role in various environmental and social aspects, providing a sustainable source of seedlings that support forest regeneration, biodiversity, soil stabilization, and carbon sequestration. The FOCUS-Mizoram project has developed nurseries at the local level to assist farmers in growing both agricultural and horticultural produce. These nurseries can be self-sustaining or maintained with government funds, ensuring their longevity and reliability.

Figure 20: Impact on Nursery Establishment



Increased Green Cover

Nurseries support the growth of a variety of plant species, contributing significantly to forest regeneration and expansion. By cultivating a diverse range of seedlings, nurseries enhance the vegetative cover of an area, restoring degraded lands and expanding forested regions. This increase in green cover helps improve local climate conditions, enhances the aesthetic value of landscapes, and provides a myriad of ecological benefits, such as improved air quality and increased habitat for wildlife.

Biodiversity Support

By growing indigenous species such as Bird Eye Chilli, Puakzo, nurseries enhance local biodiversity and provide habitats for various organisms. These indigenous plants support local wildlife, including insects, birds, and mammals, by offering food and shelter. It also helps maintain the genetic diversity of the region's flora, which is vital for ecosystem resilience and adaptability to changing environmental conditions.

Soil Stabilization

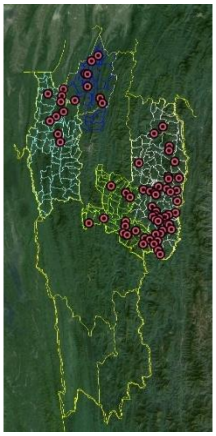
Trees and plants from nurseries help stabilize soil, preventing landslides and erosion. The roots of these plants bind the soil, reducing the likelihood of soil erosion caused by water runoff and wind. This stabilization is particularly important in preventing landslides in steep terrains and maintaining the integrity of agricultural lands. By mitigating soil erosion, nurseries contribute to preserving the fertility and productivity of farmlands.

Community and Economic Benefits

The FOCUS- Mizoram project emphasizes utilizing local materials, labor, and resources, as well as appropriate technologies, in nursery establishment. This approach reduces costs and fosters community involvement and economic benefits. By engaging local people in nursery operations, the project creates job opportunities and empowers communities. The use of locally sourced materials and labor ensures that the economic benefits of the project remain within the community, promoting local development.

4.2.3 Protection of water resources

Under the FOCUS-Mizoram project, several structures have been constructed to protect water resources. The Check dams are small barriers built across the direction of water flow on shallow rivers and streams for the purpose of water harvesting. The small dams retain excess water flow during monsoon rains in a small catchment area behind the structure. Pressure created in the catchment area helps force the impounded water into the ground. The major environmental benefit is the replenishment of nearby groundwater reserves and wells. The water entrapped by the dam, surface and subsurface, is primarily intended for use in irrigation during the monsoon and later during the dry season, but can also be used for livestock and domestic needs. The Check dams has built under FOCUS-Mizoram in a range of sizes using a variety of materials, including clay, stone and cement. Mostly masonry and reinforced cement concrete (RCC) structures has prepared.



Type of Activities	Unit	2020-21	2021-22	2022-23	2023-24	Total
Protection of water source	Sites	606	60	159	131	956

Source: Consultnat analysis

Check Dams Boost Employment Opportunities

Check dams created more employment in the beneficiary villages by increasing the number of working days for landowners. This was accomplished by increasing access to irrigation that led to:

Agricultural Intensification: This refers to more intensive cultivation of formerly rainfed or under-irrigated plots of land resulting in higher yields per hectare and requiring more person days of labour. Some lands that only produced only a single crop previously can now be double-cropped, adding an additional season of labour.

Agricultural Extensification: In some beneficiary villages, formerly barren lands have now been brought under irrigation as a direct result of the water availability with the advent of check dams. Owners of this property now have additional days of agricultural employment.

The FOCUS project's initiatives for protecting water sources involve comprehensive measures to safeguard rivers, lakes, and underground aquifers from contamination and overuse. This multifaceted approach helped the sustainability of water resources, which is essential for the well-being of local communities and the environment. The impact of these activities extends to clean water availability, water table maintenance, drought impact reduction, and ecosystem sustainability.

Figure 21: Impact of protection of water sources

Clean Water Availability

Protecting water sources ensures that communities have access to clean and safe water for drinking, agriculture, and other needs. This availability is crucial for maintaining public health, supporting food production, and ensuring daily water requirements. By preventing contamination from pollutants and safeguarding natural water bodies, the project guarantees a reliable supply of potable water, reducing the incidence of waterborne diseases and improving overall community health.

Water Table Maintenance

Protecting recharge areas helps maintain groundwater levels, which is crucial during dry seasons. By preserving and managing watersheds, the project ensures that rainwater infiltrates the ground to replenish aquifers. This practice is vital for sustaining wells and boreholes that communities rely on during periods of low rainfall. The maintenance of the water table supports long-term agricultural productivity and secures water availability for future generations. It is estimated the ground water recharge through such type of structure are around 2.21 MCM and these area covers around 3689 Ha.

Type of Activities	Unit	Total	Approx Area coverage per structure (Ha)	Water Holing Capacity per site (cubic meter)	Approx Water Storage Capacity (Lakh m^3)	No of Fillings	Estimated Gross Water Harvesting/ Storage (MCM)	Approx Ground Water Recharge (MCM)	Approx Area coverage due to structure (Ha)
Protection of water source	Sites	956	3.86	2161	1.771	2.5	4.43	2.21	3689

Source: Consultant's analysis

By preserving natural water sources, the FOCUS-Mizoram project helped communities withstand periods of low rainfall, reducing their vulnerability to drought. Initiatives such as constructing check dams and rainwater harvesting structures capture and store rainwater, making it available during dry spells in Mizoram. These measures not only mitigate the impact of droughts but also improve the resilience of communities to climate variability, ensuring that water remains accessible even in challenging times.

Ecosystem Sustainability

Healthy water sources support local ecosystems, providing habitats for aquatic life and maintaining ecological balance. By protecting rivers, lakes, and wetlands, the project fosters biodiversity, promoting the survival of various species. These ecosystems play a critical role in maintaining environmental health, as they regulate water quality, support fish populations, and provide recreational and aesthetic value to communities.

Socio-economic Benefits

Check dams, constructed as part of the water conservation strategy, have created significant employment opportunities in beneficiary villages by increasing the number of working days for landowners. This is achieved by enhancing access to irrigation, leading to:

Agricultural Intensification: More intensive cultivation of previously rainfed or under-irrigated plots results in higher yields per hectare, requiring more labor. Fields that once produced a single crop can now support multiple cropping cycles, providing additional employment and increasing agricultural productivity.

Agricultural Extensification: Formerly barren lands are now irrigated, bringing new areas under cultivation. Property owners benefit from additional agricultural employment days, transforming unproductive lands into productive ones.

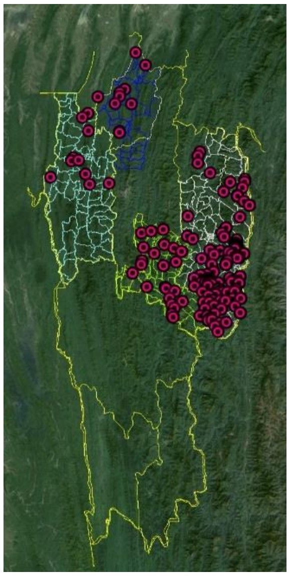
4.2.4 Water Storage & Delivery System

Most farmers in Mizoram rely on rain-fed agriculture, which means that during the dry spells of the season, no cultivation can be done. To enable year-round farming and overcome water scarcity during the dry season, the FOCUS project has implemented water storage and delivery systems in the project areas. Given that the majority of rainfall occurs during the monsoon season, irrigation is crucial to ensure an adequate water supply during dry periods.

Type of Activities	Unit	2020-21	2021-22	2022-23	2023-24	Total
Water Storage & Delivery System	Per System	214	100	318	183	815
Water Harvesting Structure	Nos	-	62	52	107	221

Source: Consultant's analysis

The water storage structures developed under the FOCUS project have significantly benefited agricultural activities by providing a reliable water source during dry spells. These structures help maintain soil moisture, ensuring that crops can continue to grow even when rainfall is insufficient. This consistent water supply allows farmers to cultivate their land throughout the year, improving crop yields and overall agricultural productivity.



In addition to supporting agriculture, the water storage structures also provide substantial benefits for domestic use. They ensure a stable supply of drinking water for local communities, which is particularly important during dry seasons when water sources can become scarce. This dual benefit of supporting both agricultural and domestic water needs enhances the overall resilience and sustainability of the communities in the project areas.

Benefits to Agricultural Activities

These water storage structures developed under the FOCUS-Mizoram project have significantly benefited small scale agricultural activities by providing a reliable water source during dry spells. These structures help maintain soil moisture, ensuring that crops can continue to grow even when rainfall is insufficient. This consistent water supply allows farmers to cultivate their land throughout the year, improving crop yields and overall agricultural productivity for small farmers. In some villages through solar pumps the water can draw from the river and store in these structures.

By capturing and storing water through river, rain or other source at project site, these systems ensure that water is available when needed, reducing reliance on erratic rainfall. This conservation of water resources is vital in maximizing the utility of available water. During field observation it has found that with a reliable water supply, farmers grown a variety of crops throughout the year, enhancing food security and economic stability. This allows for multiple cropping cycles and diversification of crops, which can improve dietary diversity and income sources for farmers.

Benefits to Domestic Use

In addition to supporting agriculture, the water storage structures also provided substantial benefits for domestic use. These structures ensured a stable supply of drinking water for local communities, which is particularly important during dry seasons when water sources can become scarce in some of the project districts. This dual benefit enhances the overall resilience and sustainability of the communities in the project areas.

The typical ground water recharge calculation has been observed and the approximate ground water recharge has been estimated in the below table.

Type of Activities	Unit	Total	Approx Area coverage per structure (Ha)	Water Holing Capacity per site (cubic meter)	Approx Water Storage Capacity (Lakh m^3)	No of Fillings	Estimated Gross Water Harvesting/ Storage (MCM)	Approx Ground Water Recharge (MCM)	Approx Area coverage due to structure (Ha)
Water Storage & Delivery System	Per System	815	1.48	8861.11	7.222	2.5	18.05	9.03	1203.6
Water Harvesting Structure	Nos	221	1.45	20.11	0.004		0.004		321.2

Source: Consultant's analysis

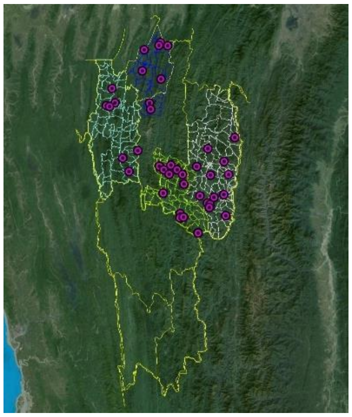
During the project, it was estimated that approximately 9.03 million cubic meters (MCM) of groundwater were recharged due to water storage and delivery system activities.

4.2.5 Bench Terrace

Bench terracing is a soil conservation practice extensively supported by the FOCUS-Mizoram project, particularly benefiting landless households in project districts. This method involves the construction of step-like fields on slopes to create flat surfaces for farming. The primary objectives of bench terracing include reducing runoff, minimizing soil erosion, conserving soil moisture and fertility, and facilitating cropping operations. Despite the high cost and implementation challenges, bench terracing promotes intensive land use and permanent agriculture on slopes, significantly reducing the practice of shifting cultivation. Most of this operation work was done manually by the farmers in their own respective field. During the project period it has report around 945 Ha area was covered. The year wise are area covered under the bench terrace activity are given below:

Type of Activities	Unit	2020-21	2021-22	2022-23	2023-24	Total
Bench Terrace	Ha	237	231	137	340	945

Source: Consultant's analysis



Bench terracing is a major activity aimed at preventing soil erosion and improving water table recharge. The estimated quantity of water recharge is detailed in the table below:

Type of Activities	Unit	Total	Approx Area coverage per structure (Ha)	Water Holing Capacity per site (cubic meter)	Approx Water Storage Capacity (Lakh m^3)	No of Fillings	Estimated Gross Water Harvesting/ Storage (MCM)	Approx Ground Water Recharge (MCM)	Approx Area coverage due to structure (Ha)
Bench Terrace	Ha	945	1.44	1150.94	0.816	2.5	2.04	1.02	1359.5

Source: Consultant's analysis

Figure 22: Impact of Bench Terrace

Source: Consultant's analysis

Soil Erosion Reduction

Bench terracing effectively reduces soil erosion by slowing down the flow of water across sloped terrains. The steps created by terracing act as barriers that interrupt the downhill movement of water, preventing it from gaining speed and carrying away the topsoil. By minimizing soil erosion, bench terracing retains the fertile topsoil, which is rich in organic matter and essential nutrients. This preservation of topsoil ensures that crops have a nutrient-rich layer to grow in, enhancing agricultural productivity and sustaining soil health over the long term.

Improved Water Infiltration

One of the significant benefits of bench terracing is improved water infiltration. The flat surfaces of the terraces allow rainwater to soak into the ground more effectively, rather than running off the slopes. This increased infiltration replenishes groundwater reserves and maintains higher soil moisture levels, which is crucial for crop growth. By enhancing water infiltration, bench terracing supports the establishment of deep-rooted plants and helps in maintaining soil structure and fertility.

Increased Arable Land

Bench terracing converts otherwise unproductive sloped land into flat, arable land, significantly increasing the amount of cultivable area. Slopes that were previously unsuitable for farming due to steep gradients and high erosion risk become valuable agricultural land. This transformation allows farmers to expand their cultivation area, leading to higher overall crop production. By making more land available for farming, bench terracing helps meet the food and economic needs of landless and smallholder farmers.



Enhanced Soil Moisture Retention

The structure of bench terraces enhances soil moisture retention, which is particularly beneficial during dry spells. The terraces trap rainwater and allow it to percolate into the soil slowly, maintaining consistent soil moisture levels. This retention of water helps crops withstand periods of low rainfall and reduces the need for frequent irrigation. Enhanced soil moisture retention also supports the growth of cover crops and other vegetation, which further stabilizes the soil and reduces erosion.

Environmental Sustainability

Bench terracing plays a critical role in promoting environmental sustainability by reducing soil erosion and runoff, which are major causes of land degradation. By maintaining soil fertility and structure, terracing helps in preserving the agricultural potential of hilly areas. The practice also supports biodiversity by creating stable habitats for various plant and animal species. Moreover, the reduction in shifting cultivation minimizes deforestation and forest degradation, contributing to the conservation of forest ecosystems.

Bench terracing, supported by the FOCUS project, is a transformative soil conservation practice that addresses both environmental and socio-economic challenges in project districts. By reducing soil erosion, improving water infiltration, increasing arable land, and enhancing soil moisture retention, bench terracing ensures sustainable agricultural practices on sloped lands.

Chapter 5

Recommendations

5.1 Soil health improvement and mitigation plan

Soil modification due to changes in land use types and patterns is a major threat to sustainable productivity of the soil and is considered one of the major factors that affect the distribution patterns of nutrients in the soil. Mizoram is drastically affected by land use change particularly, shifting cultivation, closely linked to ecological, socio-economic, cultural and land tenure systems of tribal communities profoundly affects the soil fertility and crop productivity.

Soil organic carbon (SOC) is the key indicator of soil health which acts as a store house for the nutrients, maintaining physical condition of soil and supports soil biota communities. The technological options which have been found to be efficient for soil sequestration include green manuring/manuring, mulching, conservation tillage and agroforestry. It is generally perceived.

Mizoram has primarily sand-loamy and clay-loamy soil rich in organic carbon and moderately rich in available potash. Due to high rainfall during May to September, soil is acidic ranging from 4.5-5.6 pH. The fertility of soils is affected by the cultivation practices employed by the people, soil erosion, landslides associated with high intensity rainfall and hailstorm.

In Mizoram, due to limited availability of irrigation, agriculture is entirely dependent on the rainwater from the driving monsoon downpours. The unfavourable physical conditions do not facilitate irrigated crop production, leading to only 5% of the total area under cultivation and 11% of the total cultivated area under irrigation. The principal crop is Paddy and others are Maize, Cucumber, Beans, Arum, Ginger Mustard sesame, Cotton etc. Paddy continues to remain the chief food crop and the staple food of the Mizos. It occupies almost 50% of the total cropped area and more than 88% of the total area under food grains.

In spite of the fact that the rice being the most important crop occupying the largest share in area and production, Mizoram is still not self-sufficient in rice production. Moreover there was decline of production in last few years. The traditional method of Paddy cultivation in the hill slopes, commonly known as Jhuming, has been practiced from the time immemorial in Mizoram. The cultivation of jhum paddy is for a period of one year only. After harvest in the month of November- December, the jhum is left uncultivated and shift to another virgin forest area for the next jhum practice. Impact of increased pressure on land, particularly forest land led to shrinkage of 10 years Jhum cycle to 4-5 year cycle lowering productivity and production thus rendering Jhum practice uneconomical and environmentally unfriendly. Also pressure on land has made Jhum size small and shrinkage of Jhum cycle cause low productivity, resulting in poor income for the farmers. Thus the continuous exposure of land due to short jhumming cycle to climate variability's like high intensity rainfall, cyclonic winds lead to massive landslides and erosion leaving the land barren and unfertile overtime, increasing the area under land degradation. Mizoram has experienced land degradation at an alarming rate owing to slash-and-burn system of cultivation totalling to 20.64% of the state.

Mizoram, a region with steep slopes hills in North-east India have undergone different land use change with more than 60% of the total population depending on small scale agricultural practices as it is the main source of livelihood for rural areas. The significant reduction in Jhum area is mainly due to the implementation of Oil Palm and Rubber plantation.

For sustainable agriculture practices through adoption of practices such as soil and water conservation; water conservation through efficient and assured irrigation practices; developing climate resilient cropping pattern etc. This activity/work most suitable to the existing different soil as mentioned below:-

a) Promotion of Direct seeded rice cultivation
b) SRI, System of Rice Intensification
c) Assistance for improved cultivation on hill slop
d) Farmers' Field School
e) Adoption of Integrated Pest Management for improving crop yields
f) Custom Hiring Centers (CHC)

Reduce Inversion Tillage and Soil Traffic

Excessive tillage is harmful to soil health in a number of ways. Tillage increases oxygen in the soil, stimulating microbial activity, and results in the decomposition of organic matter. Tillage also disrupts soil aggregates, exposing particles of organic matter that had been physically protected within aggregates to microbial consumption. If additions of organic matter are not sufficient to counteract the losses from decomposition, organic matter levels will decline over time, reducing soil health. Inversion tillage also

Soil Compaction

Soil compaction occurs when soil is exposed to excessive foot and equipment traffic while the soil is wet and plastic. This traffic compresses the soil, reducing pore space and increasing bulk density. Macropores are compressed more so than micropores, leading to poor water infiltration and drainage and increased runoff. Soil compaction increases soil hardness, making it more difficult for plant roots to grow through the soil. The reduction in pore space also affects habitat for many soil organisms that are very small, cannot move soil particles, and are restricted to existing pore space and channels in the soil.

Physical disturbances such as inversion tillage can also have profound effects on the biological properties of soil. Compaction and removal of surface residue may contribute to reduction in soil moisture and living space for soil-dwelling organisms. Diversity and abundance of arthropod predators associated with the soil surface can be greater under conservation tillage management in comparison to conventional inversion tillage, and natural control of pest insects in soil may be enhanced in conservation tillage systems. Beneficial insects associated with the soil are more likely to survive in fields where noninversion (e.g., chisel **ploughe**d) tillage is used. In comparison with inversion tillage practices (e.g., mouldboard **plough**), noninversion tillage causes less soil disturbance and thus less direct mortality of beneficial soil organisms.

Some tillage is still a necessary practice in certain production systems, especially organic systems that do not use herbicides for weed control. When tillage is used, it is important to offset the increased rate of organic matter decomposition with increased inputs of organic matter through crop residues, manure, and compost. Integrating several years of a perennial forage crop into a rotation with annual crops that require tillage is one way to reduce tillage intensity over time.

Increase Organic Matter Inputs

To maintain or increase soil organic matter levels, inputs of organic matter must meet or exceed the losses of organic matter due to decomposition. Healthy crops can be a valuable source of organic matter, and crop residues should be returned to the soil to the extent possible. Incorporation of cover crops or perennial crops and judicious additions of animal and green manure and compost can also be used to increase or maintain soil organic matter. Soil organic matter content can be monitored over time if you request an organic matter analysis when submitting soil fertility samples to your soil testing laboratory. Be sure that your organic matter comparisons over time are based on data from the same lab or from labs that use the same procedure for organic matter analysis, as results can differ significantly between analysis methods.

Utilise Cover Crops

Cover crops contribute numerous benefits to soil health. They keep the soil covered during the winter and other periods of time when crops are not growing, reducing the risk of erosion. The biomass produced by cover crops is usually returned to the soil, enhancing organic matter levels. Cover crops with taproots can create macropores and alleviate compaction. Fibrous-rooted cover crops can promote aggregation and stabilize the soil. Species of cover crops that host mycorrhizal fungi can sustain and increase the population of these beneficial fungi. Legume cover crops can add nitrogen to the soil through nitrogen fixation. Cover crops can retain nitrate and other nutrients that are susceptible to leaching losses.

Minimize Pesticide Usage and Create Habitats for Beneficial Organisms

Beneficial insects that contribute to biological control or pest organisms can be harmed by the application of broad-spectrum insecticides. Farm scaping is a whole-farm, ecological approach to increase and manage biodiversity with the goal of increasing the presence of beneficial organisms. Farm scaping methods include the use of insectary plants, hedgerows, cover crops, and water reservoirs to attract and support populations of beneficial organisms such as insects, spiders, amphibians, reptiles, bats, and birds that parasitize or prey on insect pests. Farm scapes placed in contours between fields, steep ditches, or places that are easily eroded give stability to the soil. Farm scaping can also be used as a filter strip to prevent water runoff and soil erosion. Plants used in farm scapes contribute to healthy soil by adding organic matter, the base of the soil food web.

Crop Rotation

Diverse crop rotations will help break up soilborne pest and disease life cycles, improving crop health. Rotations can also assist in managing weeds. By growing diverse crops in time and space, pests that thrive within a certain crop are not given a chance to build their populations over time. Rotating crops can also help reduce nutrient excesses.

Nutrient Management

Carefully planning the timing, application method, and quantity of manure, compost, and other fertilizers will allow you to meet crop nutrient demands and minimize nutrient excesses. Healthy, vigorous plants that grow quickly are better able to withstand pest damage. However, overfertilizing crops can increase pest problems. Increasing soluble nitrogen levels in plants can decrease their resistance to pests, resulting in higher pest density and crop damage.

Maintaining a soil pH appropriate for the crop to be grown will improve nutrient availability and reduce toxicity. Maintaining adequate calcium levels will help earthworms thrive and improve soil aggregation.

Using diverse nutrient sources can help maintain soil health. Manure and compost add organic matter as well as an array of nutrients, but using just compost or manure to meet the nitrogen needs of the crop every year can result in excessive phosphorus levels in the soil. Combining modest manure or compost additions to meet phosphorus needs with additional nitrogen inputs from legume cover or forage crops in a crop rotation can help balance both nitrogen and phosphorus inputs.

Maintaining residue on the soil surface helps to suppress weeds, conserve moisture, and provide habitat for insect predators.

***Managing Nutrients in Soil (**Nitrogen (N) Management)*

Although research on the benefit of leguminous to soil health is limited in Mizoram, the advantages of N fixers had been recognized worldwide. In Mizoram, the main cropping patterns available are rice mono-cropping in low lands, upland rice as a sole or intercropped with vegetables followed by soyabean etc. Legumes such as pegion pea, french bean, cow pea and soy bean are the widely gown legumes in Mizoram. This crops should be included in any possible combination as a catch crop, intercrop and fallow crop e.g. after the harvest of lowland rice. It should be noted that legumes are efficient in N fixation and improves soil health through a symbiotic association with Rhizobium besides its advantages as a green manure. The use of azolla, an aquatic fern is gaining importance, because of its symbiotic relationship with anabaena to fix nitrogen. It has been widely use in China and Philippines along lowland rice. Thus its inclusion to lowland rice may be promising. Pegion peas and other legumes can also be planted after the harvest of upland jhum rice and thus second year fallow may be utilized.

- Nitrate nitrogen is prone to leaching losses due to the molecule's negative charge, which is not retained by cation exchange sites in soil particles. Leaching primarily occurs during the fall, winter, and early spring seasons.
- Nitrogen in urea-containing fertilizers and manure can be lost through volatilization, releasing as ammonia gas if not incorporated into the soil.
- Nitrate nitrogen may be lost to the atmosphere through conversion into nitrous oxide and nitric oxide gases by microorganisms in warm, poorly aerated soil conditions.
- To minimize nitrogen losses, it's essential to apply fertilizers and manures at the appropriate timing and incorporate them into the soil.
- Using cover crops can help reduce leaching losses during the winter season

Phosphorus (P) Management

- Phosphorus is tightly bound to soil particles and does not easily diffuse through the soil.
- Mycorrhizal fungi can assist plant roots in P acquisition in low-P soils.
- Adding organic matter can mask the P binding sites on soil particles, increasing P availability.
- Phosphorus can accumulate to excessively high levels when P inputs in manure and fertilizer exceed P removal by crops; this can occur in soil that receives annual manure applications at rates to supply crop nitrogen needs.
- Erosion can transport soil particles with high levels of P into waterways where P can become a pollutant.
- Environmental P pollution can be limited by reducing erosion and maintaining soil P levels in the optimum range of 30–50 ppm Mehlich 3P.

Mitigation Plan of soil health change

Mitigating the impacts of soil health changes in the agriculture sector requires a specific customized method that addresses both short-term and long-term challenges. Here are some ways and means to achieve this:

Reviewing cultivation methods

The cultivation of soil has changed over the years; different systems have developed as technology has advanced. Such as Ploughing is traditionally the primary method of cultivation, and it provides many positive aspects for soil structure – turning the soil, burying the remains of previous crops, releasing nutrients to plants, aerating the soil and controlling weeds – key roles in crop establishment in arable soils.

But cultivation releases the carbon stored to the atmosphere as CO_2 and it can also have negative impacts on earthworms and other soil organisms, as well as increased energy costs. As climate and weather patterns change, cultivation practices will change as well.

Aiming for better nutrient balance

Nutrients are critical for crop growth and good yields. As organic matter decomposes the nutrients are incorporated into the soil and made available to plants. Farmers and growers need to have effective plans in place for optimum nitrogen and phosphorus use, and match applications to the growing crop requirements where possible.

Excessive use of inorganic or organic fertilisers can have a detrimental effect on the wider environment. Application of nitrogen and phosphorus in organic and inorganic fertilisers decreased between 2000 and 2020, with an estimated soil nutrient balance for nitrogen decreasing by 17% and phosphorus by 27%.

Soil testing and metrics

Healthy soil maintains a balanced combination of physical, chemical, and biological properties. However, many farmers lack soil health cards and are unaware of their soil's characteristics. Implementing regular soil testing under the FOCUS initiative within project areas could provide valuable insights. This would enable farmers to make more informed decisions regarding fertilizer use, leading to improved agricultural outcomes.

Testing soil should be accessible for farmers and growers, and it’s important to make sure that the soil test and the soil laboratory used are consistent to provide more accurate results.

Soil-health indicator

Through regular soil health monitoring system, the below parameter needs to measures.

Metrics for monitoring and measuring soil health are as below:

- Diseased leaves, weeds and areas of bare soil provide indicators to allow precision application.
- Leaf nitrogen analysis: Mobile apps can perform leaf nitrogen analysis to assess more accurately a crop’s requirements from the soil.
- Remote sensors collect soil data at varying landscape scales.

Indicators of the Comprehensive Assessment of Soil Health and what they mean.

Physical	**Available Water Capacity:** reflects the quantity of water that a disturbed sample of soil can store for plant use. It is the difference between water stored at field capacity and at the wilting point and is measured using pressure chambers.
	Surface Hardness: is a measure of the maximum soil surface (0 to 6 inch depth) penetration resistance (psi), or compaction, determined using a field penetrometer.
	Subsurface Hardness: is a measure of the maximum resistance (psi) encountered in the soil between 6 to 18 inch depths using a field penetrometer.
	Aggregate Stability: is a measure of how well soil aggregates resist disintegration when hit by rain drops. It is measured using a standardized simulated rainfall event on a sieve containing soil aggregates between 0.25 and 2.0 mm. The fraction of soil that remains on the sieve determines the percent aggregate stability.

Biological	**Organic Matter:** is a measure of all carbonaceous material that is derived from living organisms. The percent OM is determined by the mass of oven dried soil lost on combustion in a 500° C furnace.
	Soil Protein: is a measure of the fraction of the soil organic matter which contains much of the organically bound N. Microbial activity can mineralize this N and make it available for plant uptake. This is measured by extraction with a citrate buffer under high temperature and pressure.
	Soil Respiration: is a measure of the metabolic activity of the soil microbial community. It is measured by re-wetting air dried soil, and capturing and quantifying carbon dioxide (CO_2) produced.
	Active Carbon: is a measure of the small portion of the organic matter that can serve as an easily available food source for soil microbes, thus helping fuel and maintain a healthy soil food web. It is measured by quantifying potassium permanganate oxidation with a spectrophotometer.
	Add-on Indicators: **Root Pathogen Pressure Rating:** is a measure of the degree to which sensitive test-plant roots show symptoms of disease when grown in standardized conditions in assayed soil. Assessed by rating washed roots through visual inspection for disease symptoms. **Potentially Mineralizable Nitrogen:** is a combined measure of soil biological activity and substrate available to mineralize nitrogen to make it available to the plant. It is measured as the change in mineralized plant-available nitrogen present after a seven-day anaerobic incubation.
Chemical	**Soil Chemical Composition:** a standard soil test analysis package measures levels of pH and plant nutrients. Measured levels are interpreted in this assessment's framework of sufficiency and excess but no crop specific recommendations are provided.
	Add-on Indicators: **Salinity and Sodicity:** Salinity is a measure of the soluble salt concentration in soil and is measured via electrical conductivity. Sodicity is a calculation of the sodium absorption ratio (SAR) and is measured using ICP spectrometry to determine $Na+$, Ca_2+, Mg_2+ concentrations and using an equation to calculate the absorption ratio. **Heavy Metals:** is a measure of levels of metals of possible concern to human or plant health. They are measured by digesting the soil with concentrated acid at high temperature.

Mizoram is classified as "Eastern Himalayan Region" together with six other northeastern states, characterised by high rainfall, high forest cover, heavy soil erosion and floods. Mizoram State is further divided into three sub-agro-climatic zones, namely: Humid Mild Tropical Hill Zone situated in the western side of the state; Humid Subtropical Hill Zone in the central part of the state; and Humid Temperate Subalpine Zone in the eastern side. Below table gives the geographic features and characteristics of the respective agro-climatic zones.

Table 10 : Geographic and Characteristic Features of Agro-climatic Zones in Mizoram

Agro-climatic Zone	Altitude Range (AMSL, m)	Annual Average Rainfall (mm/year)	Mean Temperature (Max~Min) (°C)	Administrative District	Major Farming System
Humid Mild Tropical Hill Zone	200 ~ 800	2,000 ~ 3,000	30 ~ 12	- Kolasib (North) - Mamit (West) - Lunglei (West) - Laungtlai (West and Centre) - Saiha (West)	Irrigated paddy and various horticulture crops taking advantage of moderate slope and water
Humid Subtropical Hill Zone	1,000 ~ 1,500	2,500 ~ 3,000	30 ~ 12	- Kolasib (South) - Mamit (East) - Aizawl (except Southeast) - Serchip (West and Centre) - Lunglei (Center) - Lawngtlai (East) - Saiha (Centre)	Mixed cropping of upland rice with vegetables predominantly in jhum culture for self-sufficiency
Humid Temperate Sub-alpine Zone	1,500 ~	2,000 ~ 3,000	11 ~ 20	- Aizawl (Southeast) - Champai - Serchip (East) - Lunglei (East edge) - Lawngtlai (East edge) - Saiha (East)	Self-sufficient agriculture relying on jhum, cropping upland rice and horticulture crops on steep slope

Source: Consultant's Analysis

5.2 Best Practices for of Soil and Water Conservation

Through years of farming experience, farmers have acquired knowledge about the interconnections between slope, stream-flow, and soil formation independently. As a result, they have developed alternative water-harvesting and recycling/irrigation techniques. Several of these techniques are outlined below:

5.2.1 Stone bunds

Stone bund is a popular technique in stony areas and is a practical method of clearing stones from cultivated land. On one hand stones are removed from the fields and on the other, same stones are used to construct the stone bunds to conserve the soil and water. Their permanent nature makes them more popular with farmers than trash lines but these are labour intensive. These barriers of stones are placed at regular intervals along the contour. The length of the stone bunds varies between 0.5 -50 m and may be 5 to 10 m apart, depending on the availability of stones and the topography. The bunds made as an outer wall of terraces are of 10 – 50 m length but those made to reduce the runoff velocity of a rivulet may be of 0.5 to 2 m length. The bunds are semi-permeable, allowing water to

pass through but retain soil and this process leads to the formation of natural bench terraces over time. On older farms, the bunds are very large wall like structures, built with large stones on the outer and the inner side is filled in with smaller stones. These large bunds may take several years to be completed, with a new course of stones being laid each season as time allows. In Chekawn village coming under East Lungdar block of Serchip district such traditional wisdoms of stone bunding is widely practiced by the farmers for checking soil erosion as well as siltation of wet rice cultivation (WRC) areas. Graded bunds made up of boulders have been converted in to terraces due to subsequent siltation over time. These terraces are used for paddy cultivation during kharif. Such kinds of boulder bunds have been constructed on the upstream side of the hillock and the excess water is slowly passed into low lying paddy fields for WRC.

5.2.2 Pit digging method

This is essentially a soil and water conservation system as well as a fertility restoration technique, through in-situ decomposition of grasses, weeds and agricultural waste materials such as paddy straw, maize stover, etc. Field is cleaned and square grids are made by making the lines in the field at one-meter intervals. Soil is then dug from the centre of the grid up to 30-60 cm deep and 100 cm diameter pits are made. Then the grasses are placed in the pits and some soil is filled to cover the grass. Pits are left for some time for decomposition of grasses. Pits are dug to break the continuity of the surface and direct the water underground. The pits, from a distance resemble a honeycomb. Pits for growing of paddy is dug horizontally in straight line as far as practicable, but vertically they are not in straight line, rather they are like the legs of a trivet. The advantage of digging in trivet is that the top soil so removed while weeding will be carried down to the pits. The rainwater collected in the pits, percolates into the soil slowly while the incorporated crop residues improve soil fertility. This technique is very similar to mound digging.

5.2.3 Earthen bunds

This is essentially an erosion control and water harvesting technique. To check the soil erosion and conserve the water farmers are subdividing the fields in to several small plots by making earthen bunds about 0.5 m high. This technique is found in wet land rice cultivation areas in whole state. These are used mainly for water harvesting from the upper reaches for rice production and for slowing down runoff. Earthen bunds are also constructed for reducing runoff in maize and sorghum fields where they are usually constructed along the contour after planting the crop. These types of bunds are constructed by digging a trench about 25 cm deep with the scooped soil forming embankments or ridges.

5.2.4 Traditional ditches

Traditional ditches are made to allow excess water to infiltrate easily and drain out of cultivated land, to the side of an artificial or natural waterway. A ditch may sometimes be dug on the upper side of the cultivated land to act as a cut off drain to protect the field from the runoff coming from the upper reaches. Thus, traditional ditches drain excess water from the field, protect the soil from being washed away and reduce surface runoff generated within the cultivated land.

5.2.5 Ridges

Ridges have traditionally been associated with the growing of specific crops such as beans, groundnuts, sweet potatoes and cassava. Ordinary ridges are 20-50 cm high and are usually spaced between 60-80 cm. When they are laid across the slope, they control the soil erosion. Ridges also improve the soil fertility through in-situ composting of vegetation that is buried under during ridge formation. In some areas, broad-based ridges are evolved, furthering more the concept of soil fertility restoration with the incorporation of more grasses, and trashes.

5.3 Indigenous agriculture, horticulture crops and practices

Mizoram's agriculture is influenced by its diverse topography and distinctive climatic conditions. The FOCUS project seeks to bolster the resilience of local farming by identifying and advocating for indigenous crops and horticultural practices. This report delves into the appropriateness of these crops and practices across different soil health scenarios, with a key emphasis on enhancing farmers' livelihoods and fostering sustainable agriculture.

Indigenous Agriculture and Horticulture Crops

In Mizoram, indigenous agricultural and horticultural crops play a crucial role in maintaining soil health and ensuring food security. Upland rice, often cultivated through jhum (shifting) cultivation, is drought-tolerant and suitable for sloping terrains. This type of rice requires less water and adapts well to shifting cultivation methods, maintaining soil structure with minimal inputs. In contrast, wetland rice, suitable for valley bottoms with high water availability, has a high yield potential and supports water retention in soils, requiring good soil fertility and water management practices.

Mizo beans (Vigna spp.) and chickpeas (Cicer arietinum) are important pulse crops that contribute to soil fertility through nitrogen fixation. Mizo beans enhance soil organic matter and nutrient cycling, providing protein-rich food, while chickpeas, being drought-resistant, are suitable for various soil types and help in nitrogen fixation and soil structure improvement. Indigenous vegetables like bitter gourd (Momordica charantia) and taro (Colocasia esculenta) thrive in tropical climates and moist soils, respectively. Bitter gourd is nutritious and has a high market demand, with minimal impact on soil health, while taro, requiring well-drained soils, improves soil moisture retention.

Indigenous fruits such as bananas (Musa spp.) and pineapples (Ananas comosus) also contribute to sustainable agriculture in Mizoram. Bananas thrive in humid conditions and benefit from organic mulching, requiring nutrient-rich soils, while pineapples, growing well on slopes and being drought-resistant, enhance soil aeration and prevent erosion.

Indigenous Agricultural Practices

Indigenous agricultural practices in Mizoram are tailored to the region's topography and climate, promoting sustainable land use and soil health. Jhum cultivation involves clearing forest patches, cultivating for a few years, and then leaving the land fallow to regenerate. This practice promotes biodiversity and adapts well to hilly terrains but can lead to soil erosion if not managed properly. Mixed cropping, the practice of growing multiple crops simultaneously, reduces pest and disease risks and improves soil fertility by enhancing nutrient cycling and soil structure.

Agroforestry, the integration of trees and shrubs into agricultural landscapes, provides multiple products such as timber, fruits, and fodder while improving biodiversity. This practice enhances soil fertility, prevents erosion, and improves water retention. Terrace farming, which involves creating terraces on slopes to reduce erosion and runoff, conserves soil and water, making it suitable for rice and vegetable cultivation. Terraces prevent soil erosion and enhance water retention, contributing to sustainable agriculture.

Soil Health Change Scenarios and Adaptation Strategies

Soil health in Mizoram faces various challenges, including soil degradation, nutrient depletion, and moisture deficiency. In scenarios of soil degradation and erosion, the loss of topsoil, reduced fertility, and increased runoff can be mitigated by implementing terracing, contour farming, using vegetative barriers, and promoting reforestation and agroforestry to enhance soil stability. When dealing with soil nutrient depletion, characterized by a decline in organic matter and nutrient deficiencies, adopting crop rotation with legumes, using organic fertilizers and compost, and practicing mixed cropping can enhance soil fertility.

In scenarios of soil moisture deficiency due to drought and reduced water availability, implementing efficient irrigation techniques such as drip and sprinkler systems, promoting drought-resistant crops, and creating water storage structures are effective adaptation strategies. These measures help in maintaining soil moisture, ensuring crop productivity, and enhancing overall soil heal

Chapter 6

Theory of change & Future Roadmap

The study provides a comprehensive analysis of resource use assessment and the impact of soil and water conservation activities in Mizoram. In Chapter 3, the focus is on examining the current practices related to resource utilization in the region. This involves assessing how land, water, and other natural resources are being utilized by local communities, as well as understanding any existing challenges or issues.

Following this assessment, Chapter 4 delves into the impact of soil and water conservation activities in Mizoram. It evaluates the effectiveness of various conservation initiatives and identifies areas where improvements can be made. Recommendations are provided to address shortcomings and enhance the outcomes of conservation efforts.

Moving forward, it is crucial to consider the key aspects of the overall study, including the theory of change. The theory of change serves as a guiding framework for setting up a future roadmap. It outlines the causal pathways through which interventions lead to desired outcomes. By understanding these pathways, stakeholders can develop strategic plans and allocate resources more effectively to achieve long-term sustainability and resilience in Mizoram's ecosystems.

6.1 Policy Level Interventions

The Policy-level intervention will help in the success of soil and water conservation initiatives such as the FOUCS project. To effectively address the pressing environmental concerns, it is imperative to formulate robust policies that identify key issues and integrate FOUCS with other government programs. This necessitates fostering interdepartmental collaboration to streamline efforts, aligning FOUCS objectives with national policies, ensuring adequate institutional support and stakeholder engagement, implementing incentive mechanisms to promote adoption, and prioritizing research and innovation. By incorporating these recommendations, FOUCS can maximize its impact and contribute significantly to sustainable land and water management practices.

Some of the key policy level interventions are described in the figure below

Figure 23: Policy Level Interventions for SWC activities

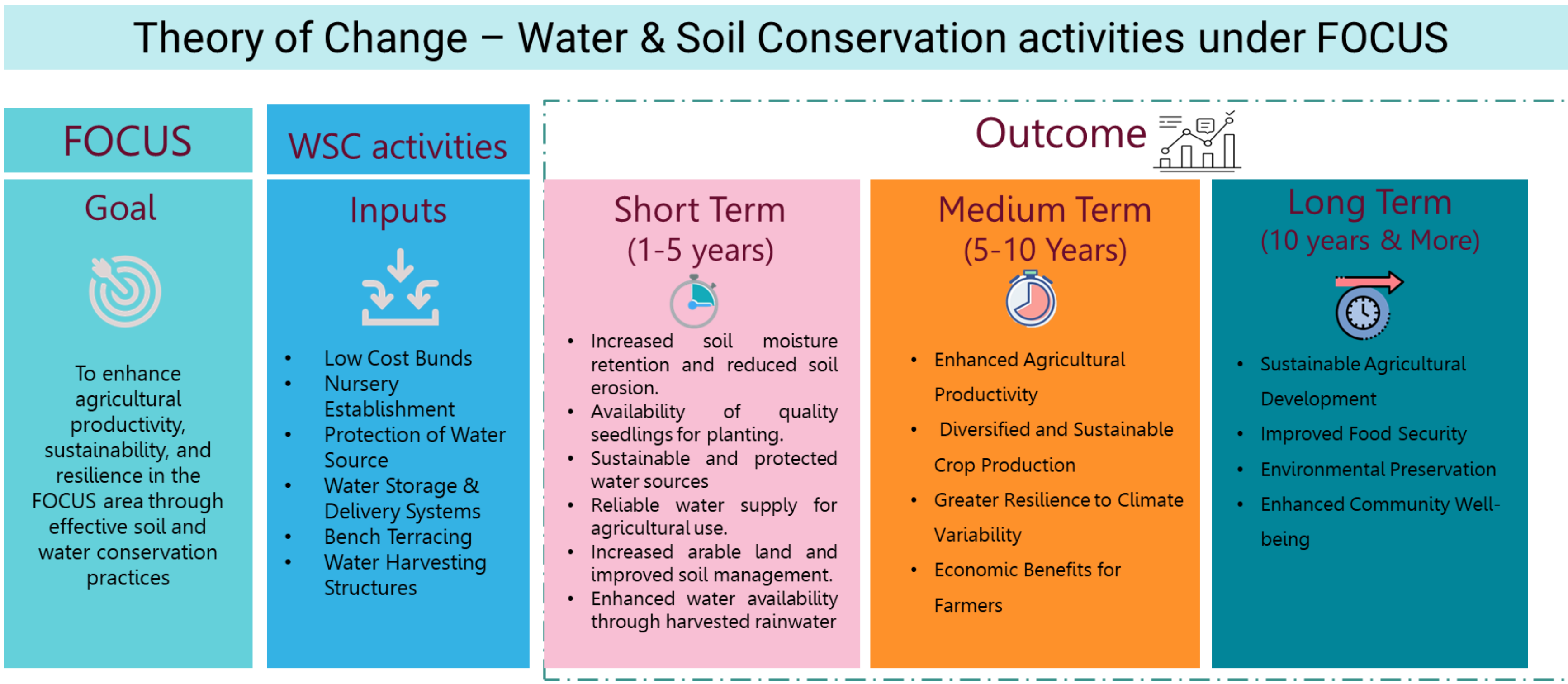
Potential area	Description
Integrated Watershed Management	• Develop and implement watershed management plans that involve local communities, government agencies, and other stakeholders. • Promote land-use practices that minimize soil erosion and maximize water retention. • Support reforestation and afforestation efforts, especially with native species
Sustainable Agricultural Practices	• Promote contour plowing, terracing, and agroforestry to reduce soil erosion. • Introduce and subsidize drip irrigation and other water-efficient irrigation systems. • Provide training and resources for organic farming and the use of cover crops to enhance soil fertility and structure.
Afforestation and Reforestation Programs	• Implement large-scale afforestation and reforestation projects in degraded hill areas. • Involve local communities in tree planting and maintenance activities. • Protect existing forests from illegal logging and encroachment.
Water Conservation and Management	• Develop rainwater harvesting systems to capture and store runoff for agricultural and domestic use. • Implement policies for the construction and maintenance of small-scale water storage facilities such as ponds and tanks. • Promote the efficient use of water through public awareness campaigns and incentives for water-saving technologies.
Community Participation and Capacity Building	• Establish community-based organizations (CBOs) to manage local conservation projects. • Provide training programs for community members on soil and water conservation techniques. • Develop incentives and support mechanisms for community-led initiatives.
Regulatory Framework and Incentives	• Enforce land-use regulations that prevent deforestation and unsustainable agricultural practices. • Provide financial incentives such as subsidies, and grants for farmers and landowners who adopt conservation practices. • Convergence of scheme into the Soil and water conservation activities • Penalize activities that lead to soil degradation and water pollution.

Source: Consultant's Analysis

6.2 Theory of Change

The theory of change may involve identifying the inputs (such as funding, technical expertise, and community participation), activities (such as implementing conservation measures, conducting awareness campaigns, and capacity building), outputs (such as increased adoption of sustainable practices, improved soil and water quality), outcomes (such as enhanced livelihoods, biodiversity conservation), and impacts (such as resilience to climate change, improved well-being of communities). The theory of change into the development of future strategies and initiatives, policymakers, practitioners, and communities can work collaboratively towards achieving sustainable resource management and environmental conservation goals in Mizoram.

Figure 24 Theory of Change – SWC activities under FOCUS



Source: Consultant's analysis

6.3 Future Roadmap

The future roadmap for sustainable soil and water conservation in Mizoram, designed through the FOUCS project, hinges on a comprehensive assessment of both positive and negative impacts of current activities. Key positive impacts include improved soil health, enhanced water retention, and increased biodiversity preservation, alongside robust community engagement. However, challenges such as initial implementation costs, resistance to change among local farmers, and limited resources need addressing. The roadmap outlines a continuous review and assessment process to evaluate ongoing interventions and adapt strategies accordingly. Strengthening institutional frameworks and ensuring regular stakeholder collaboration are vital to streamline efforts and resources, leveraging partnerships with entities like ASSAC, Dept of Horticulture, Dept of Agriculture and Land Resources, Soil & Water Conservation Department.

Additionally, the roadmap emphasizes the convergence of FOUCS initiatives with other government programs to amplify impact and achieve holistic ecosystem development. This includes integrating with schemes like the National Rural Employment Guarantee Act (NREGA) for funding and labor support, aligning with state-level rural development efforts, and exploring innovative financing mechanisms such as climate adaptation funds. Capacity building for local communities through training and workshops, coupled with policy advocacy for supportive measures and incentives, will drive the adoption of sustainable practices. By fostering a collaborative, well-supported, and continuously adaptive approach, Mizoram can ensure the long-term success of its soil and water conservation efforts, contributing significantly to the region's environmental and economic sustainability.

Table 11 : Future Road Map

Key Parameters	Project Activities	Positive Impacts	Negative Impacts	Future Action Plan
Construction of Terraces,	Control of loss of topsoil; Sustainable development of soil and water resources in Mizoram's hilly terrain	Changes in farm pests' category and quantity due to crop variety changes; Impacts on water quality due to pesticide and fertilizer usage, Improve Agriculture productivity	Adopt biological and physical measures to prevent pests; use high-efficiency and low-toxicity pesticides; promote ecological agriculture and organic fertilizers; strengthen management of fertilizer and pesticide usage	Construction of Terraces and encourage to shift Jhum cultivation
Sediment Retention Structures	Check dams, water retraining structure, Gabion structure, irrigation canals, channels, riverbanks	Reduction of sediment flowing downstream in Mizoram's rivers	Destruction of surface vegetation and increased soil erosion in some regions; minor impacts on water and air quality	Construct in winter; restore destroyed vegetation; ensure reservoir safety

Key Parameters	Project Activities	Positive Impacts	Negative Impacts	Future Action Plan
Afforestation and Vegetation Cover (forests and shrubs)	Plantation of indigenous trees; grazing ban for natural regeneration	Increased vegetation coverage; enhanced biodiversity; improved biological structures; optimized land use in Mizoram's forests	Potential food security impacts due to excessive farmland reforestation; risks from exotic pests and diseases; forest fire hazards; minor impacts on water and air quality	Optimize project design; implement reforestation based on specific watershed conditions; control wasteland; plant multi-species forests; enhance forest protection and quarantine measures; avoid planting non-native species; manage forest pests and diseases with natural enemies and preventive measures
Village Infrastructure	Drinking water supply systems, small reservoirs, rehabilitation of access roads, bridges to cross the rivers for goods	Improved agricultural production conditions and access to clean water in Mizoram's villages	Destruction of surface vegetation and increased soil erosion due to construction activities	Construct in winter; manage construction waste; restore destroyed vegetation
Basic Farmland Improvement/ Construction	Terracing of sloped land with deep soils; riverbank control	Control of loss of topsoil; sustainable development of soil and water resources in Mizoram	Changes in farm pests' category and quantity due to crop variety changes; impacts on water quality due to pesticide and fertilizer usage	Adopt biological and physical measures to prevent pests; use high-efficiency and low-toxicity pesticides; promote ecological agriculture and organic fertilizers; strengthen management of fertilizer and pesticide usage
Livestock	Breeding cattle, pigs, Mithun, sheep, poultry	Increase of farmers' income; improved biological and protection forests	Aggravate grassland degradation and soil erosion due to excessive grazing; pollute water quality with livestock waste	Develop breeding industry responsibly and implement enclosed breeding; use manure applying and biogas pits to dispose of livestock waste and use organic waste in the agriculture crop
Irrigation	Small-scale facilities (e.g., tanks and cisterns filled by runoff, pumping schemes, stream diversion)	Improved agricultural production conditions, leading to increased harvests	Destruction of surface vegetation and increased soil erosion due to construction activities	Construct in winter; manage construction waste; restore destroyed vegetation

The FOCUS project covered the SDG Goal 1,2,5,6,8,12,13,14, and 15 number

Figure 25: SDG coverage by FOCUS

Annexures

Annexure 1: District wise assessment of Agriculture and Horticulture crop

1. Mamit District

Agricultural crops

Mamit district thrives on agriculture, with a large portion of its residents relying on it for their income. Despite its importance, agriculture faces hurdles like limited access to modern farming methods, lack of proper irrigation systems, and dependence on unreliable weather. The district's hilly landscape is dotted with rural communities were agriculture reigns supreme. Rice, maize, Tapioca, Pulses, Oilseeds, Sugarcane and Potato are the main crops cultivated here. Jhum cultivation, a traditional method of shifting cultivation, is also commonly practiced in the region.

This table provides data on the area, production, and yield of major agricultural crops in Mamit district for three financial years (FY) - 2019-20, 2020-21, and 2021-22. Overall production has increased across the three years, from 4749 MT in 2019-20 to 7266 MT in 2021-22. This indicates a positive trend in agricultural output. Average yield (P/A) shows fluctuations. It was highest in 2019-20 (1.85) and dipped in 2020-21 (1.22) before recovering somewhat in 2021-22 (1.54). This suggests factors affecting efficiency alongside the production increase.

Area, Production & Yield of Agricultural crops in Mamit District (FY 2019-20 to 2021-22)										
S. N	Name of Crops	2019-20			2020-21			2021-22		
		A	P	Yield (P/A)	A	P	Yield (P/A)	A	P	Yield (P/A)
1	Cereals (Rice)	2878	3787	1.32	2398	2972	1.24	3692	5056	1.37
2	Maize	987	1175	1.19	979	1143	1.17	477	511	1.07
3	Tapioca	0	0	0.00	250	530	2.12	17	51	3.00
4	Pulses	511	508	0.99	502	494	0.98	203	315	1.55
5	Oilseeds	252	184	0.73	217	160	0.74	120	89	0.74
6	Sugarcane	102	3071	30.11	0	0	0.00	100	1206	12.06
7	Potato	19	83	4.37	0	0	0.00	99	38	0.38
Total		4749	8808	1.85	4346	5299	1.22	4708	7266	1.54
A- Area in Ha, P- Production in MT & Y-Yield in P/A										

Source: Mizoram Statistical Database, Directorate of Economics & Statistics, Government of Mizoram

Horticultural crops

Horticulture is the main cash crop in the district. The Agro-climatic conditions, fertile soil and abundant rainfall are favourable for horticultural fruits like oranges, banana, rubber, oil palm, arecanut and crops like paddy and vegetables like cabbage, cauliflower, tomatoes, leafy vegetables, ginger etc. The diversification of crops would increase the production and income of the growers, which would in turn boost the economy of the district. Arrangement for export of orange and squash may boost the economy of the district.

This table provides data on the area, production, and yield of horticultural crops in Mamit District for the fiscal years 2019-20 to 2021-22. There's a fluctuation in the area used for cultivation, with an increase from 2019-20 to 2021-22. Production follows a lightly similar pattern, decreasing from 2019-20 to 2020-21 and then increasing in 2021-22. The yield per unit area (P/A) shows some variation across the years. It decreases slightly from 2019-20 to 2020-21 but increases in 2021-22 as shown in the below table. It seems there might be some challenges or factors influencing the cultivation and production of horticultural crops in Mamit District, leading to these fluctuations.

Area, Production & Yield of Horticultural Crops in Mamit District (FY 2019-20 to 2021-22)										
S. N	Districts	2019-20			2020-21			2021-22		
		A	P	Yield (P/A)	A	P	Yield (P/A)	A	P	Yield (P/A)
1	Fruits	7.25	27.02	3.73	7.64	28.29	3.70	7.67	28.29	3.69
2	Vegetables	1.85	13.95	7.55	4.09	17.06	4.17	4.13	17.09	4.14
3	Plantation, Medicinal & Spices	8.92	29.99	3.36	8.26	20.92	2.53	9.61	31.28	3.26
4	Roots, Tubers & Floriculture	0.03	5.38	189.26	0.03	5.38	189.26	0.03	5.38	189.26
Total		18.04	76.33	4.23	20.02	71.65	3.58	21.44	82.04	3.83
A- Area in 000 Ha, P- Production in 000 MT & Y-Yield in P/A										

Source: Mizoram Statistical Database, Directorate of Economics & Statistics, Government of Mizoram

2. Kolasib District

Agricultural crops

Kolasib district boasts a distinctive and diverse crop arrangement. Its rugged topography and favorable climate combine to form an excellent agricultural setting. Rice, maize, Tapioca, Pulses, Oilseeds, Sugarcane and Potato are the main crops cultivated here. Rice stands out as the predominant staple, extensively grown throughout the district. Maize cultivation holds its own prominence, playing a pivotal role in the area's economy. The cropping mosaic of Kolasib district underscores the ingenuity and proficiency of its farming populace, fostering a sustainable and flourishing agricultural sector.

The below table shows the district wise Area, Production & Yield of Agricultural crops (FY 2017-18 to 2021-22)". It shows the average crop production and yield of agricultural crops in Kolasib district, from 2019 to 2022. The district of Kolasib has seen a slight increase in crop area from 2019-20 to 2021-22. In 2019-20, the area under cultivation was 7.92 hectares, and in 2021-22, it was 7.73 hectares. Crop production has fluctuated over the same period. In 2019-20, production was 20.80 metric tons, and it increased to 20.47 metric tons in 2021-22. Crop yield has also fluctuated. In 2019-20, yield was 2.63 metric tons per hectare, and it decreased to 2.65 metric tons per hectare in 2021-22. Overall, the data suggests that there has been little change in crop production and yield in Kolasib district over the past three years.

Area, Production & Yield of Agricultural crops in Kolasib District (FY 2019-20 to 2021-22)										
S. N	Name of Crops	2019-20			2020-21			2021-22		
		A	P	Yield (P/A)	A	P	Yield (P/A)	A	P	Yield (P/A)
1	Cereals (Rice)	5610	11350	2.02	5414	12042	2.22	5362	11965	2.23

Area, Production & Yield of Agricultural crops in Kolasib District (FY 2019-20 to 2021-22)										
S. N	Name of Crops	2019-20			2020-21			2021-22		
		A	P	Yield (P/A)	A	P	Yield (P/A)	A	P	Yield (P/A)
2	Maize	871	1522	1.75	872	1548	1.78	893	1561	1.75
3	Tapioca	32	374	11.69	53	632	11.92	48	567	11.81
4	Pulses	771	1120	1.45	872	1277	1.46	957	1410	1.47
5	Oilseeds	438	458	1.05	486	567	1.17	297	426	1.43
6	Sugarcane	199	5973	30.02	0	0	0.00	146	4415	30.24
7	Potato	0	0	0.00	0	0	0.00	28	129	4.61
	Total	7921	20797	2.63	7697	16066	2.09	7731	20473	2.65
A- Area in Ha, P- Production in MT & Y-Yield in P/A										

Source: Mizoram Statistical Database, Directorate of Economics & Statistics, Government of Mizoram

Horticultural crops

Kolasib district is known for its diverse horticultural practices due to its favorable climate and soil conditions. Here's an overview of some of the prominent horticultural crops cultivated in Kolasib district. The major horticultural crops include Fruits like banana, oranges, papaya, Pineapples etc., Vegetables, Plantation, Medicinal & Spices, Roots, Tubers & Floriculture. Bananas are extensively grown in Kolasib district due to the tropical climate and well-distributed rainfall. Varieties such as Dwarf Cavendish and Robusta are commonly cultivated. Bananas are not only a significant source of income for farmers but also contribute to local consumption. Various vegetables such as tomatoes, cabbage, cauliflower, and beans are grown in Kolasib district both for local consumption and commercial purposes. With increasing urbanization and changing dietary habits, the demand for fresh vegetables is on the rise. Floriculture is also gaining momentum in Kolasib district. Flowers like orchids, roses, and gladiolus are cultivated for both domestic use and export purposes. The district's cool climate is conducive to the cultivation of a wide variety of flowers.

The below table depicting the Area, Production, and Yield of Horticultural Crops in Kolasib District from the fiscal year 2019-20 to 2021-22. The total area, production, and yield of horticultural crops in Kolasib District showed an increasing trend over the three years. The area increased from 14.44 thousand hectares to 18.79 thousand hectares, production increased from 85.98 thousand metric tons to 93.32 thousand metric tons, while the yield per hectare experienced a slight decline from 5.95 to 4.97.

Overall, horticulture plays a vital role in the agricultural economy of Kolasib district, offering diverse opportunities for income generation and contributing significantly to the livelihoods of the local population.

Area, Production & Yield of Horticultural Crops in Kolasib District (FY 2019-20 to 2021-22)										
S.N	Districts	2019-20			2020-21			2021-22		
		A	P	Yield (P/A)	A	P	Yield (P/A)	A	P	Yield (P/A)
1	Fruits	7.00	26.49	3.78	7.68	27.67	3.61	7.70	27.67	3.60
2	Vegetables	2.19	14.07	6.43	4.44	19.17	4.32	4.50	19.22	4.27
3	Plantation, Medicinal & Spices	5.22	26.49	5.08	3.81	17.37	4.56	6.56	27.49	4.19

Area, Production & Yield of Horticultural Crops in Kolasib District (FY 2019-20 to 2021-22)										
S.N	Districts	2019-20			2020-21			2021-22		
		A	P	Yield (P/A)	A	P	Yield (P/A)	A	P	Yield (P/A)
4	Roots, Tubers & Floriculture	0.04	18.94	531.25	0.04	18.94	531.25	0.04	18.94	531.25
Total		14.44	85.98	5.95	15.96	83.15	5.21	18.79	93.32	4.97
A- Area in 000 Ha, P- Production in 000 MT & Y-Yield in P/A										

Source: Mizoram Statistical Database, Directorate of Economics & Statistics, Government of Mizoram

3. Champhai District

Agricultural crops

The district's economy hinges primarily on its agricultural sector, with over half of its population relying on farming for sustenance. Traditional methods like terraced cultivation and shifting cultivation (known as Jhum) are prevalent practices. The district boasts a diverse range of agricultural products including Rice, maize, Tapioca, Pulses, Oilseeds, Sugarcane and potatoes. Champhai valley, renowned as "The Rice Bowl of Mizoram," stands out for its highest rice production in the state.

The below table provides data on the area, production, and yield of agricultural crops over three fiscal years: 2019-20, 2020-21, and 2021-22. There is a decrease in the area of cultivation from 2019-20 to 2021-22, indicating a potential shift or reduction in agricultural activity. Despite the decrease in area, there's a slight increase in production from 2019-20 to 2021-22. This suggests a possible improvement in productivity or efficiency in farming methods. The yield per unit area (P/A) fluctuates over the years. It decreased from 2.08 in 2019-20 to 1.98 in 2020-21 and then increased to 2.33 in 2021-22. This could be due to various factors such as changes in agricultural practices, weather conditions, or crop types.

Overall, while there's a decrease in the area under cultivation, the production has shown a slight increase, indicating some level of optimization or efficiency in agricultural practices in Champhai district over the mentioned fiscal years.

Area, Production & Yield of Agricultural crops in Champhai District (FY 2019-20 to 2021-22)										
S. N	Name of Crops	2019-20			2020-21			2021-22		
		A	P	Yield (P/A)	A	P	Yield (P/A)	A	P	Yield (P/A)
1	Cereals (Rice)	8470	15424	1.82	6092	12611	2.07	4626	11380	2.46
2	Maize	468	768	1.64	480	768	1.60	749	1162	1.55
3	Tapioca	14	25	1.79	2	9	4.50	4	19	4.75
4	Pulses	321	380	1.18	284	274	0.96	344	337	0.98
5	Oilseeds	154	137	0.89	80	70	0.88	43	40	0.93
6	Tobacco	181	324	1.79	0	0	0.00	182	78	0.43
7	Sugarcane	97	3137	32.34	0	0	0.00	74	1072	14.49
8	Potato	35	50	1.43	0	0	0.00	43	70	1.63
	Total	9740	20245	2.08	6938	13732	1.98	6065	14158	2.33
A- Area in Ha, P- Production in MT & Y-Yield in P/A										

Source: Mizoram Statistical Database, Directorate of Economics & Statistics, Government of Mizoram

Horticultural crops

Champhai district in Mizoram has a diverse crop pattern with a focus on both agriculture and horticulture. Major horticultural crops cultivated in the district includes Fruits like oranges, papaya, banana etc., Vegetables, Plantation, Medicinal & Spices, Roots, Tubers & Floriculture. The district's favourable climate and fertile soil contribute to the cultivation of high-quality produce, enhancing the local economy and food security. The cultivation of both field crops and horticultural crops plays a crucial role in sustaining livelihoods, ensuring food security, and contributing to the economic development of the district.

The total area under horticultural crops in Champhai District increased from 12.66 thousand Ha in 2019-20 to 16.99 thousand Ha in 2021-22, reflecting an expansion in overall horticultural production. Total production of horticultural crops also exhibited growth, rising from 83.70 thousand MT in 2019-20 to 103.57 thousand MT in 2021-22. This indicates a successful increase in output. However, the overall yield (Y) of horticultural crops showed a slight decline, from 6.61 in 2019-20 to 6.10 in 2021-22. This could be due to the expansion of lower-yielding vegetable cultivation or other factors requiring further investigation.

Area, Production & Yield of Horticultural Crops in Champhai District (FY 2019-20 to 2021-22)										
S.N	Districts	2019-20			2020-21			2021-22		
		A	P	Yield (P/A)	A	P	Yield (P/A)	A	P	Yield (P/A)
1	Fruits	8.31	44.04	5.30	8.39	44.61	5.31	8.48	44.61	5.26
2	Vegetables	1.81	17.20	9.52	4.46	34.90	7.83	4.49	34.94	7.78
3	Plantation, Medicinal & Spices	2.49	10.11	4.06	1.17	2.22	1.90	3.97	11.70	2.95
4	Roots, Tubers & Floriculture	0.05	12.34	235.42	0.05	12.32	244.42	0.05	12.32	244.42
Total		12.66	83.70	6.61	14.07	94.05	6.68	16.99	103.57	6.10
A- Area in 000 Ha, P- Production in 000 MT & Y-Yield in P/A										

Source: Mizoram Statistical Database, Directorate of Economics & Statistics, Government of Mizoram

4. Serchhip District

Agricultural crops

Serchhip District in Mizoram showcases a unique land use pattern, shaped by its geography and socio-economic dynamics. The region's utilization of land predominantly revolves around agriculture and main occupation of the people in the district particularly characterized by terraced cultivation prevalent across its hilly terrain. These terraced fields, adorned with lush greenery, serve as the bedrock for major agricultural crops such as rice, maize, Pulses. Oilseeds, Oil Palm, Sugarcane and Potatoes are crucial for sustaining the local peoples.

The below table presents data on the area, production, and yield of various agricultural crops in Serchhip District for the fiscal years 2019-20 to 2021-22. The total area under cultivation fluctuated slightly, from 7926 hectares in 2019-20 to 7643 hectares in 2021-22. Total production showed more significant fluctuations, with the highest production of 31619 metric tonnes in 2019-20 and the lowest of 13064 metric tonnes in 2020-21. The overall yield per hectare varied from 3.99 metric tonnes in 2019-20 to 4.08 metric tonnes in 2021-22, showing minor fluctuations over the period.

Table : Area, Production & Yield of Agricultural crops in Serchhip District (FY 2019-20 to 2021-22)										
S. N	Name of Crops	2019-20			2020-21			2021-22		
		A	P	Yield (P/A)	A	P	Yield (P/A)	A	P	Yield (P/A)
1	**Cereals (Rice)**	4237	7851	1.85	4246	7862	1.85	4242	7783	1.83
2	**Maize**	1593	3167	1.99	1593	3148	1.98	1532	3162	2.06
3	**Pulses**	784	851	1.09	784	851	1.09	800	871	1.09
4	**Oilseeds**	792	1116	1.41	792	1116	1.41	549	887	1.62
5	**Oil Palm**	0	0	0.00	740	87	0.00	0	0	0.00
6	**Sugarcane**	520	18634	35.83	0	0	0.00	520	18480	35.54
7	**Potato**	0	0	0.00	0	0	0.00	0	0	0.00
	Total	**7926**	**31619**	**3.99**	**8155**	**13064**	**1.60**	**7643**	**31183**	**4.08**
A- Area in Ha, P- Production in MT & Y-Yield in P/A										

Source: Mizoram Statistical Database, Directorate of Economics & Statistics, Government of Mizoram

Horticultural crops

The agro-climatic conditions with fertile soil and abundant rainfall is favorable for horticulture crops such as banana, pineapple, passion fruit, hatkora, orange and vegetables includes cabbage, cauliflower, tomato, etc are the major Crops are grown. There are teak plantations in the district also.

The below table shows that, the total area under horticultural crops increased from 19.70 thousand hectares in 2019-20 to 25.57 thousand hectares in 2021-22. Total production also exhibited a rising trend, increasing from 134.89 thousand MT to 153.74 thousand MT over the period. However, the overall yield per hectare decreased slightly from 6.85 in 2019-20 to 6.01 in 2021-22, suggesting potential challenges in maintaining or improving productivity as cultivation expands.

It is predicted that, area, production, and yield of horticultural crops in Serchhip District indicates overall growth in cultivation and production levels over the three fiscal years. However, challenges in maintaining or improving yield per hectare are evident, particularly in the case of vegetables and plantation/medicinal/spices crops. Strategies to address these challenges, such as enhancing agricultural practices, improving infrastructure, and promoting technological interventions, may be necessary to sustainably support the growth of the horticultural sector in the district.

Table : Area, Production & Yield of Horticultural Crops in Serchhip District (FY 2019-20 to 2021-22)										
S.N	Districts	2019-20			2020-21			2021-22		
		A	P	Yield (P/A)	A	P	Yield (P/A)	A	P	Yield (P/A)
1	**Fruits**	11.32	82.61	7.30	11.52	85.89	7.46	11.57	85.89	7.42
2	**Vegetables**	3.92	22.41	5.71	6.68	35.92	5.38	7.83	36.68	4.69
3	**Plantation, Medicinal & Spices**	4.42	13.58	3.07	2.85	5.14	1.80	6.12	14.87	2.43

Table : Area, Production & Yield of Horticultural Crops in Serchhip District (FY 2019-20 to 2021-22)										
S.N	Districts	2019-20			2020-21			2021-22		
		A	P	Yield (P/A)	A	P	Yield (P/A)	A	P	Yield (P/A)
4	Roots, Tubers & Floriculture	0.04	16.29	395.44	0.05	16.30	306.41	0.05	16.30	306.41
Total		**19.70**	**134.89**	**6.85**	**21.10**	**143.26**	**6.79**	**25.57**	**153.74**	**6.01**
A- Area in 000 Ha, P- Production in 000 MT & Y-Yield in P/A										

Source: Mizoram Statistical Database, Directorate of Economics & Statistics, Government of Mizoram

5. Saitual District

Agricultural crops

Agriculture is the backbone of the local economy in Saitual district, providing employment and sustenance to a significant portion of the population. Majority of the residents in Saitual district are directly or indirectly dependent on agriculture for their livelihoods. The cultivation of crops, coupled with innovative farming practices, helps sustain the local economy and supports the overall development of the region. The main crop grown here is rice, which is a staple diet for the locals. Other crops that benefit from the ideal climate and fertile soil include maize, pulses, oilseeds, sugarcane, and potatoes. This varied range of crops not only meets the population's nutritional needs, but also adds to the region's agricultural diversity.

The below table showcasing the area, production, and yield of agricultural crops in Saitual District for the fiscal years 2020-21 to 2021-22. The total area under cultivation increased from 2263 hectares in 2020-21 to 3082 hectares in 2021-22, indicating an expansion in agricultural activity. Similarly, the total production rose from 3768 MT to 5480 MT during the same period, signifying increased output. Notably, the overall yield improved from 1.67 metric tonnes per hectare to 1.78 metric tonnes per hectare, suggesting enhanced efficiency or productivity in crop cultivation.

Table : Area, Production & Yield of Agricultural crops in Saitual District (FY 2020-21 to 2021-22)							
S. N	Name of Crops	2020-21			2021-22		
		A	P	Yield (P/A)	A	P	Yield (P/A)
1	**Cereals (Rice)**	2263.00	3768.00	1.67	2298.00	3470.00	1.51
2	**Maize**	0.00	0.00	0.00	348.00	608.00	1.75
3	**Tapioca**	0.00	0.00	0.00	4.00	6.00	1.50
4	**Pulses**	0.00	0.00	0.00	191.00	256.00	1.34
5	**Oilseeds**	0.00	0.00	0.00	193.00	222.00	1.15
6	**Tobacco**	0.00	0.00	0.00	4.00	4.00	1.00
7	**Sugarcane**	0.00	0.00	0.00	41.00	908.00	22.15
8	**Potato**	0.00	0.00	0.00	3.00	6.00	2.00
	Total	**2263.00**	**3768.00**	**1.67**	**3082.00**	**5480.00**	**1.78**
A- Area in Ha, P- Production in MT & Y-Yield in P/A							

Source: Mizoram Statistical Database, Directorate of Economics & Statistics, Government of Mizoram

6. Khawzawl District

Agricultural crops

The economy of Khawzawl district thrives predominantly on agriculture, serving as the cornerstone occupation for the majority of its inhabitants. The fertile terrain lends itself favorably to the cultivation of staple crops like Rice, Maize, Tapioca, Pulses, Oilseeds and Sugarcane. The agricultural bounty not only fulfills local dietary needs but also finds its way to neighboring markets, contributing to regional trade.

Rice stands as the flagship crop of Khawzawl district, serving as the linchpin of its agricultural prosperity. Benefitting from the fertile soils and conducive climate, rice cultivation flourishes within the region. Farmers employ both rain-fed and irrigated techniques to cultivate rice, resulting in generous yields. The paddy fields of Khawzawl district yield a substantial rice harvest, catering not only to local consumption but also bolstering Mizoram's overall rice production. While other crops like maize, millet, and assorted vegetables find their place in the district's agricultural mosaic, rice remains paramount, constituting a vital source of sustenance and livelihood for the local populace.

The below table showing the area, production, and yield of agricultural crops in Khawzawl District for the fiscal years 2019-20 to 2021-22. The total production of agricultural crops has increased from 2532 MT in 2020-21 to 3008 MT in 2021-22. The total area under cultivation has also increased slightly from 1832 Ha to 1951 Ha. The overall yield has improved from 1.38 MT per hectare to 1.54 MT per hectare, indicating an overall increase in productivity per unit area. The analysis indicates an overall positive trend in agricultural performance in Khawzawl District from FY 2019-20 to 2021-22, with increases in production, slight expansion of cultivation areas, and improved productivity for most crops. However, there are some fluctuations and crop-specific challenges such as the absence of tapioca cultivation and a decrease in pulses' productivity.

Table : Area, Production & Yield of Agricultural crops in Khawzawl 2021 District (FY 2020-21 to 2021-22)

S. N	Name of Crops	2020-21			2021-22		
		A	P	Yield (P/A)	A	P	Yield (P/A)
1	**Cereals (Rice)**	1649.00	2310.00	1.40	1650.00	2595.00	1.57
2	**Maize**	102.00	127.00	1.25	144.00	216.00	1.50
3	**Tapioca**	8.00	10.00	1.25	0.00	0.00	0.00
4	**Pulses**	57.00	65.00	1.14	59.00	57.00	0.97
5	**Oilseeds**	16.00	20.00	1.25	95.00	95.00	1.00
6	**Sugarcane**	0.00	0.00	0.00	3.00	45.00	15.00
	Total	**1832.00**	**2532.00**	**1.38**	**1951.00**	**3008.00**	**1.54**
A- Area in Ha, P- Production in MT & Y-Yield in P/A							

Source: Mizoram Statistical Database, Directorate of Economics & Statistics, Government of Mizoram

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Prepared by- Greenhexa Techserve